DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE

FOREST PRODUCTS RESEARCH BOARD

With the Report of the Director of Forest Products Research

FOR THE YEAR 1931

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1931

To the Lords of the Committee of the Privy Council for Scientific and Industrial Research

May it Please Your Lordships,

WE, the Forest Products Research Board, beg leave to present our report for the year 1931.

General

1. The Forest Products Research Laboratory is now approaching the end of its fifth year as a fully organized and equipped research station at Princes Risborough. In these years a very wide range of work has been covered, much of it being preliminary to a more definite and detailed attack on the problems with which the Laboratory is primarily concerned. The fundamental work now in progress follows upon a large amount of exploratory investigation, often of an empirical nature, and two outstanding examples of this section of the Laboratory's activities are the researches on the part played by wood structure in influencing the penetration of antiseptics during preservative treatment and the endeavour to establish the principles that should govern technique in the machining of different kinds of timber. An important factor in the marked progress of the past year has been the closer contact of the staffs of the different Sections of the Laboratory, consequent upon your Lordships' action in centralizing all the work at Princes Risborough. The results have amply justified this policy of centralization. As in the previous year we can again report a considerable increase in demands for the Laboratory's services by all sections of the wood-using professions and trades, and in response we have been able to accept a much greater volume of work than would have been possible under the old arrangements.

Constitution of the Board

2. We regret to record the resignation from the Board and from the Chairmanship of the Empire Timbers Committee of Sir George L. Courthope, Bart, M.P., due to pressure of other work. We welcome the appointment of Sir John M. Stirling Maxwell, Bart, K.T., as the new Chairman of the Committee.

Large-Scale Investigations into Dry Rot and the Death-Watch Beetle

3. Investigations are now progressing in the new experimental building erected for the study of dry rot and the Death-Watch beetle under full-scale service conditions. Reference was made to this building in last year's report and, in consequence of the improved facilities which it offers, both the scope and the value of the investigations have been greatly enhanced, and practical trials of the preventive and remedial measure

indicated by laboratory research are now possible. A number of architects have inspected the building and have expressed appreciation of the great practical value of the work now in progress.

Reconditioning of Timber

4. On page 11 of his report, the Director of Research describes another development of practical importance, the results of which have already been applied industrially. In his report for 1930, particulars were given of the successful outcome of a treatment (suggested by the Australian Forest Products Laboratory for application to Tasmanian oak) by which a defect having the appearance of excessive shrinkage but due to the actual collapse of the wood cells could be remedied by high temperature steaming in a drying kiln, and he suggested that the same treatment might be equally successful in the case of other classes of defect in a variety of timbers. During the past year experiments have amply fulfilled the Director's prediction, defects such as warping, cupping and bowing in home-grown elm, beech and ash having shown the same excellent response to the treatment. Not only were the defects almost entirely removed but the material showed an unexpected and appreciable increase in width and thickness. The advantages of the reconditioning process not only in the striking improvement of the quality of the timber but in the increase of measurement, make it a valuable addition to trade practice. Mechanical tests so far carried out serve to show that the process does not impair the strength of the timber.

Timber Insect Survey

Lyctus Powder-post Beetles

5. One of the most important problems which still confront the hardwood section of the timber trade and manufacturers using hardwoods is the occurrence and spread of damage caused by the *Lyctus* Powder-post beetles. As recorded last year, an extensive survey of the position throughout the country during 1929-30 showed that this evil is widespread and is causing heavy losses. Data provided by the survey have now been collated and the conclusions will shortly be published. Reference to page 24 of the report by the Director of Research makes it clear that the trouble can no longer be ascribed solely to the importation of infested timber from abroad, for *Lyctus* has now become established in this country and occurs quite as frequently in such home-grown timbers as oak, ash and walnut as in imported timbers. The solution of the problem cannot therefore be found in legislation to prevent the importation of infested timber; and so long as concerted measures are not taken to eradicate *Lyctus* from the timber yards of this country there is little hope of persuading exporters from overseas to take action. The Laboratory has already demonstrated a practical method of steam sterilization for infected timber and has made its recommendations widely known. Evidence that these measures are effective is available from the experience of many firms who have put them into practice; but, to secure eradication, action is necessary on the part of all concerned.

Work of the Empire Timbers Committee

6. As a result of the activities of the Empire Marketing Board and of the widespread desire of the public to use Empire materials, there has been a large increase in requests for investigation and advice upon Empire timbers, and in consequence it has been necessary to place a number of investigations on the waiting list. From the evidence now assembled

by the Empire Timbers Committee, there is no doubt that, as stated by the Committee on page 2 of its report, a vigorous policy of organization and development, especially of our tropical hardwood resources, might eventually render the Empire almost, if not entirely, self-supporting in hardwoods, while there is room for a considerably increased consumption of Canadian softwoods within the Empire. At present, attempts to extend the markets for Empire timbers suffer in many cases from irregularity of supplies, lack of proper grading and seasoning, lack of knowledge of market requirements, insufficient stocks in quantity and variety available in the United Kingdom, and, in certain cases the high cost attendant on small and unorganized production. Defective supplies, moreover, add considerably to the normal cost. Foreign supplies, on the other hand, are regular, extremely well prepared, available in ample quantity and variety and cheap.

If the trade in Empire timbers is to attain the proportions of which it is capable, it is essential to strive for the same degree of efficiency, and there seems no reason why this should not be achieved. We emphasize the opinion expressed in last year's report that the first and indispensable step to this end is to carry out thorough botanical and economic surveys of the forest resources in the tropical colonies. We realize that existing Forest Service staffs are in many cases inadequate for undertaking this work, but we consider that the necessary increase should be well justified by results. Three facts seem to be beyond doubt ; that the available tropical hardwood resources are ample and suitable, that a very considerably increased trade is possible, and that the present moment provides an exceptional opportunity for securing the trade.

J. C. IRVINE,
Chairman.

May, 1932.

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1931

I.—GENERAL

Introduction

THE progress of the work of the Forest Products Research Laboratory during the year 1931 has been maintained, and increasing use has been made by the timber-using professions and industries of the results of research work which has been completed. The number of applications for investigations of Empire timbers has exceeded those of the previous year, and a full programme of tests has been carried out. There is evidence of growing appreciation of the facilities offered by the Laboratory for investigations of this nature.

Accumulation of material during the past few years has rendered the existing insectary and laboratory accommodation in the Entomology Section inadequate. Additional insectaries and an extension to the present laboratory had been contemplated during the year, but as a result of the present economic situation, their erection has had to be postponed. Temporary accommodation has been provided, but the congestion has been only partly relieved.

On the 1st December, 1931, the number of persons engaged at the Laboratory was 156, consisting of: Scientific and Technical staff, 49; Laboratory assistants, boys and girls, 20; Office Staff, 16; Foremen and Industrial Staff (including messengers and charwomen), 69. A detailed list of the Scientific and Technical staff is given in Appendix I.

Collection of Wood Specimens

With the transfer of the Section of Wood Structure to Princes Risborough, it has been possible to undertake the botanical classification and arrangement of the Laboratory's reference collection of wood specimens. The collection has now been arranged in the Wood Structure laboratory, and on December 31st, 1931, comprised a total of 4269 specimens, excluding duplicates, representing 1835 named species of 748 genera. The collection of wood specimens was begun by the Section of Utilization in 1925. At that time, requests were made to the Forestry Departments and Forest Products Laboratories in the Dominions and Colonies for collections of timber specimens and these requests met with a willing response in nearly every case. The Wembley Exhibition also afforded facilities for establishing contact with persons in a position to assist the Laboratory in building up a representative collection of Empire timbers. Further acquisitions have been made from year to year with the help of institutions and persons, in all parts of the Empire and in several foreign countries. The kindly co-operation of all concerned is gratefully acknowledged. In briefly reviewing the history of the collection, it has to be admitted that the present number of properly authenticated specimens, the specific identity of which can be accepted without question, is disproportionately small, and this is a serious drawback. The task of collecting timber specimens, properly correlated with leaves, flowers and fruit from the same tree to enable the identity of the species to be determined, offers considerable difficulties, especially in tropical

countries, and it has too often been the case that mistakes have occurred in the naming of timbers due to neglect of this precaution. This applies with special force to certain of our Colonies where shortage of staff has not permitted adequate botanical survey and collecting work to be carried out by the Forest Departments, with the result that many timbers of potential value are unrepresented in this country except by samples of doubtful authenticity. The intention is, in course of time, to replace all unauthenticated samples by specimens reliably named and duly correlated with herbarium material, but the process of replacement has hitherto been very slow and present indications are that the formation of an adequately representative collection of Empire timbers will be long delayed unless special arrangements can be made for accelerating this important work.

The International Congress of Sylviculturists in Paris, July, 1931

Two officers from the Laboratory accompanied the British Delegation to a congress of sylviculturists held in Paris in connection with the French Colonial Exhibition in July. Among the subjects discussed and which had a bearing on the work of the Laboratory, were wood structure and identification, timber mechanics, woodworking and utilization. A paper was contributed by an officer of the Laboratory on the place of wood anatomy in forest products research.

A paper on the mechanical testing of timber and on preservative treatments was also contributed to the Congress of the New International Association for testing materials held at Zurich, in September, 1931.

The Standardization of Trade Names

The multiplicity of trade names for timbers is a common cause of confusion which has led to many requests for identification being addressed to the Laboratory. One species of timber may be marketed under a variety of different names, or again, a single name may be applied to two or more different kinds of timber. A standing committee of the Empire Forestry Association, on which the Laboratory is represented, is directly concerned with the standardization of trade names for the more important Empire timbers, and there is reason to believe that the list published in the Empire Forestry Handbook is proving of value for purposes of reference. The importance of placing standardization on an international basis was recognized by the International Congress of Sylviculturists held in Paris in July, 1931 ; a formal resolution was passed to form a committee which should consider the question and bring forward proposals at the next international congress.

Exhibition of British Empire Timbers

At the Centenary Show of the Highland and Agricultural Society held at Edinburgh in June, 1931, an exhibit illustrating the work which is being done in connection with Empire timbers aroused considerable interest. The exhibit included specimen planks of seventy-six timbers representative of practically all parts of the Empire. Sample panels had been prepared to illustrate the working qualities of the various timbers, and other sections of the exhibit were illustrative of the work which has been in progress in connection with damage due to insects or fungi, and to the treatment of wood with preservatives. The numerous inquiries relating to the suitability of timbers for particular purposes, the prevention of damage by insects and decay, seasoning and other technical matters concerned with the utilization of timber testified to the value of the exhibit.

Permanent Exhibits at the Laboratory

An exhibit of planks of Empire timbers showing specimens of some 150 woods is in course of preparation for permanent display in the corridors of the main Laboratory block. A display of wrought exhibits of 61 Empire timbers, prepared to show the machining properties of the wood, has also been completed.

The display of wood manufactures and wood products has been re-arranged in the Exhibition Room.

II.—THE PROGRAMME OF RESEARCH

(*United Kingdom Division*)

Home-Grown Timber Investigations

Consignments of home-grown timbers which pass through the Laboratory for the investigation of their technical properties provide material for the routine examination of their anatomical structure, especially in regard to the variation that is caused by locality and sylvicultural conditions. It is due to this characteristic variation in wood that there can be no such thing as a true " type specimen " of any one species, and as the use of a large number of wood specimens showing the complete range of structure is generally impracticable, it is necessary to fall back on detailed technical descriptions. These, properly based on the study of a large number of different specimens showing as wide a range as possible, provide the essential basis for the comparative investigation of timbers, and it is remarkable that there is at present no authoritative work of reference to the wood structure of the timbers of the British Isles. It is intended that the systematic examination of home-grown timbers received for test, supplemented by material in the Laboratory collection, shall in due course lead to the preparation of a series of standard descriptions.

The Relation of Wood Structure to Physical Properties

Investigations have been continued into the relations existing between the anatomical structure of wood and those physical properties, in the broadest sense of the term, which determine its technical value. The study of structure as it affects the shrinkage of wood, its mechanical strength and its amenability to preservative treatment is dealt with in the appropriate sections of this report.

The Determination of Cell-Space Ratio

One of the quantities which is of considerable interest in the study of wood structure is the measurement of the " cell-space ratio " i.e., the percentage of void space per unit volume of a sample of wood due to its cellular structure. This percentage is given approximately by the percentage of void space per unit area in a thin transverse section of the sample. To measure this ratio quickly and easily, a photo-electric photometer has been devised which compares the amount of light penetrating a stained transverse section with the amount stopped out by the cell walls. When a suitable correction has been made for the small amount of light passed by the cell walls owing to their not being stained completely black, a measure of the cell-space ratio can be obtained in a short time. The correction for the partial transparency of the cell wall, though theoretically simple, is in practice a matter of considerable difficulty. So far the method has been perfected so as to allow a correction to be made for stains which transmit not more than

about 5 per cent. of the light falling on them, but for more transparent stains the correction is not so satisfactory.

Problems Associated with the Working Qualities of Timber

The chief interest of the Section of Timber Physics has been focussed on the problems associated with the working qualities of timbers, which were briefly mentioned in the last annual report. A knowledge of the fundamental processes involved in the machining of timber is very necessary where timbers new to the British market are to be dealt with by existing machinery. A new Empire timber is often condemned by the machinist as "unworkable" simply because machines, developed to deal with timbers in common use, are not suited to the very different structure of the new timber. A modification of feed speed, cutting speed or cutting angle may be all that is necessary to make the most obdurate timber workable, but in order to foretell these modifications a knowledge of the way in which the cutting action of any tool, whether plane, saw or drill, should be related to the structure of the wood on which it is to work is essential.

The Section of Timber Physics has, during the past year, collected the available information on this subject and has mapped out the general lines along which research may be expected to prove most useful. The results of this work appear in a publication which will probably appear before this annual report is completed. The bulletin is a preliminary analysis of the processes involved in woodworking, relating the mechanical and physical properties of wood to the stresses to which it is subjected under the machine, and it is hoped during the year 1932 to test out some of the tentative solutions reached.

Another side of the problem of woodworking is the measurement of the "finish" produced by the machine. The woodworker judges "finish" by the two senses—touch and sight. In order to give a quantitative measure to the finish as judged by the sense of touch, an instrument which measures the frictional resistance experienced in dragging a standard metal plate along the surface of a machined board has been in use at the Laboratory. This instrument was of an experimental type and has been subjected to rigorous quantitative tests during the year. As a result of the experience so gained a new instrument has been designed in conjunction with the Section of Utilization and is now under construction. In this new instrument many of the limitations of the former one will be removed and it will be capable of greater adaptability.

As regards the measurement of the optical qualities of finish, measurements have been made of the reflecting power, or gloss, of a machined wood surface. Fig. 1 shows the variation in the intensity of the light scattered from a planed surface of Douglas fir. The graph is such that the distance from 0 to the curve in any direction is proportional to the intensity of the scattered light in that direction. The inner curve gives the result for a machined surface; the next for a sawn surface, while the outer curve, a circle, gives the theoretical distribution for a perfectly rough surface. As an example of a very rough surface, the dotted curve shows the scattering from the surface of a piece of fine sandpaper, which is seen to approximate closely to the ideally rough surface. If we define "roughness" as the ratio of the area enclosed by the curve obtained to that of an ideally rough surface (the circle) drawn with the same normal component (the diameter from 0) we obtain a factor of roughness lying somewhere between 0 and 1. In particular, the varying degrees of roughness of the above surfaces are as follows:—

Planed surface	52·2 per cent.
Sawn surface	83·9 „
Sandpaper	93·7 „

Further investigations are being made of the possibilities of this method.

Other lines of research, in connection with the heat flow in wood and with its moisture-retaining powers, have also been initiated but these are still in their preliminary stages.

(1) The Principles of Woodworking. *Forest Products Research Bulletin* No. 13. H.M. Stationery Office, 1932. Price 2*s*. 6*d*. net.

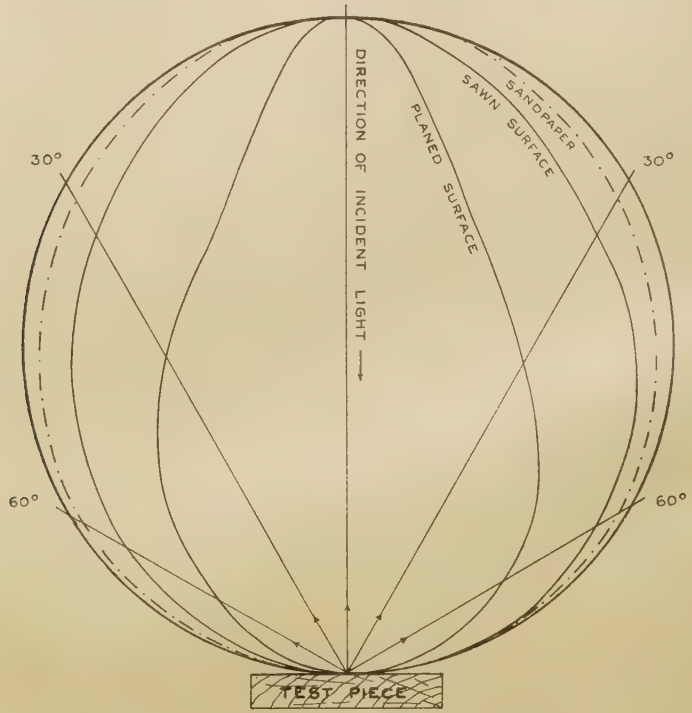


FIG. 1.—*Optical test of finish on Douglas fir.*

Planed surface	..	..	..	52·2 per cent.
Sawn „	..	..	..	83·9 „ „
Sandpaper „	..	..	..	93·7 „ „

The Shrinkage of Wood

The study of the relations between the anatomical structure of wood and the dimensional changes which accompany the loss or gain of moisture has been continued. An important characteristic of certain woods, for example, mahogany, is that the difference between the radial and tangential shrinkage for any given loss of moisture is very small. The practical significance of this fact lies in the relatively small disposition on the part of such woods to become distorted with change of moisture content. A preliminary series of experiments has been carried out with the dual object of verifying the reputed superiority of mahogany in this respect and of determining the anatomical basis for this small difference between radial and tangential shrinkage, and these experiments are being continued on slightly modified lines.

An endeavour is being made to correlate the shrinkage of wood with the amount of cupping which occurs in through-and-through sawn boards during drying, and some interesting results have already been obtained.

Measurements have been made of the shrinkage and expansion of steamed and unsteamed oak when submitted to normal humidity variations after seasoning. The results, which are again mentioned on page 10, indicated that the steaming had no practical effect on the subsequent movements.

The measurement of movement in timber consequent on temperature changes has been continued but progress has been retarded by difficulties which have arisen in making the experiments on green timber. It is hoped that these will soon be overcome and that the work will then proceed more quickly. This study is considered to be an important one, for it is likely that thermal expansion is basically allied to the movements produced by moisture changes in wood, and it is also most probably responsible for some of the surprising results obtained from the process now known as reconditioning, which is discussed later in the report.

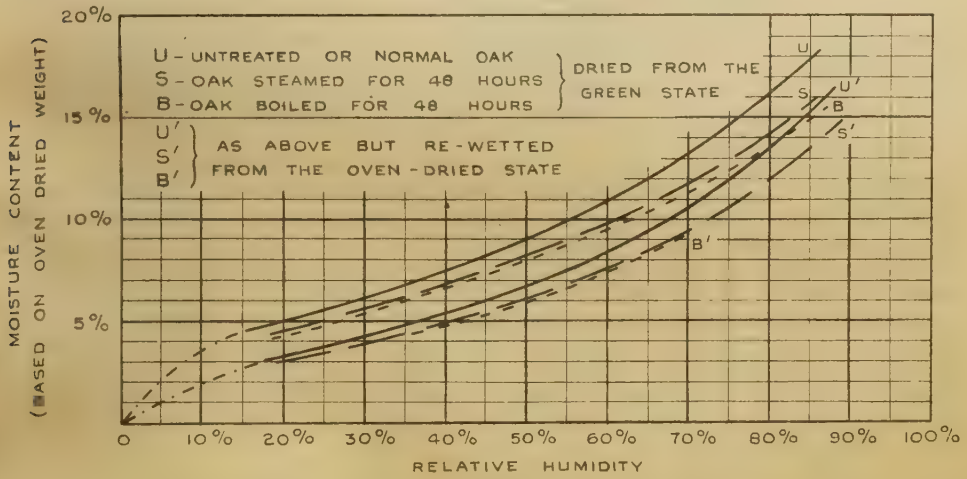


FIG. 2.—*Moisture content—humidity equilibrium curves for Oak.*

The Relations between the Moisture Content of Wood and the Surrounding Hygrometric Conditions

A study is being made of the equilibrium values of the moisture content in wood corresponding to different temperature and humidity conditions of the surrounding air. It is found that, for any hygrometric state of the air, the value of the equilibrium content differs considerably among species, and it is hoped that some indication of the reason for this will result. Experiments have already shown that the density of the species is not an important factor.

The manner in which the affinity of wood for moisture can be affected by boiling or steaming is illustrated by the curves of Fig. 2. It will be seen that for a given humidity, the steamed or boiled oak has a lower equilibrium moisture content than the untreated

material. Other observers have found that steaming, boiling, or even prolonged soaking in cold water, has the effect of reducing the " hygroscopicity " of wood, and the results obtained, therefore, merely confirm previous work. It is interesting to note, however, that the difference between the equilibrium contents corresponding to the extreme humidities of the range to which wood is normally exposed in use, say, 50 per cent. and 80 per cent., respectively, is only slightly smaller for the steamed than for the unsteamed wood. The actual figures are 8 per cent. as against 9 per cent.

It has been claimed that steaming reduces the working, i.e., the shrinkage and expansion which normally occur in wood in use, due to its exposure to humidity variations. From the experiments under review, it would appear that, if the working were seriously reduced, the reduction must be caused by a direct effect of the steaming process on the shrinkage and expansion, and not indirectly through its affecting the subsequent moisture content variations of the wood.

Actually, from an investigation recently carried out on a practical scale using oak, there appear to be no grounds for the claim that steaming reduces the working No change of practical significance could be detected in the amount of shrinkage or expansion after treatment, though there appeared to be a very slight increase in the radial and a similar decrease in the tangential movement. The equilibrium moisture content is of considerable practical importance, as it enters into the problem of seasoning timber before manufacture to suit the hygrometric condition to which it will be subsequently exposed. The shrinkage and expansion of timber in use can be minimised by seasoning it to an appropriate moisture content.

A complication arises, when, as is frequently the case, fine timberwork is to be placed in a new public building, the shell of which is freshly completed and still far from dry. The internal humidity of such a building will temporarily be considerably higher than at any subsequent time. If the timber to be installed is seasoned to suit existing conditions it must ultimately shrink, and a temporary freedom from trouble will be bought at the cost of permanent defectiveness. If, on the other hand, the timber is seasoned to suit the conditions which will prevail when the building dries out, immediate swelling will occur, and this, unless the timber has perfect freedom to move, will again result in permanent damage to the work. The only real solution to the difficulty is to expedite the drying of the new building and to delay the fixing of such work as would be liable to damage. It is gratifying to find that this problem is being more generally considered by those chiefly concerned.

Kiln-seasoning Experiments

The experimental kilns of the Laboratory, both large and small, have been kept in full employment and steady progress has resulted. Kiln experiments on a large scale have been made on home-grown oak, elm, beech, ash, chestnut, birch, larch, Corsican and Scots pines and Norway spruce, while small-scale tests of yew and alder have yielded interesting results.

Oak, from which the major growth defects were cut out in conversion, gave better results than had been obtained previously and in a shorter time. The drying period was still too long, however, to be regarded as satisfactory, and the test served to confirm previous conclusions that a preliminary air-seasoning, followed by treatment in the kiln, might be a more practical method of dealing with this and certain other hardwoods. A new project has been prepared to study the result of combining air- with kiln-seasoning.

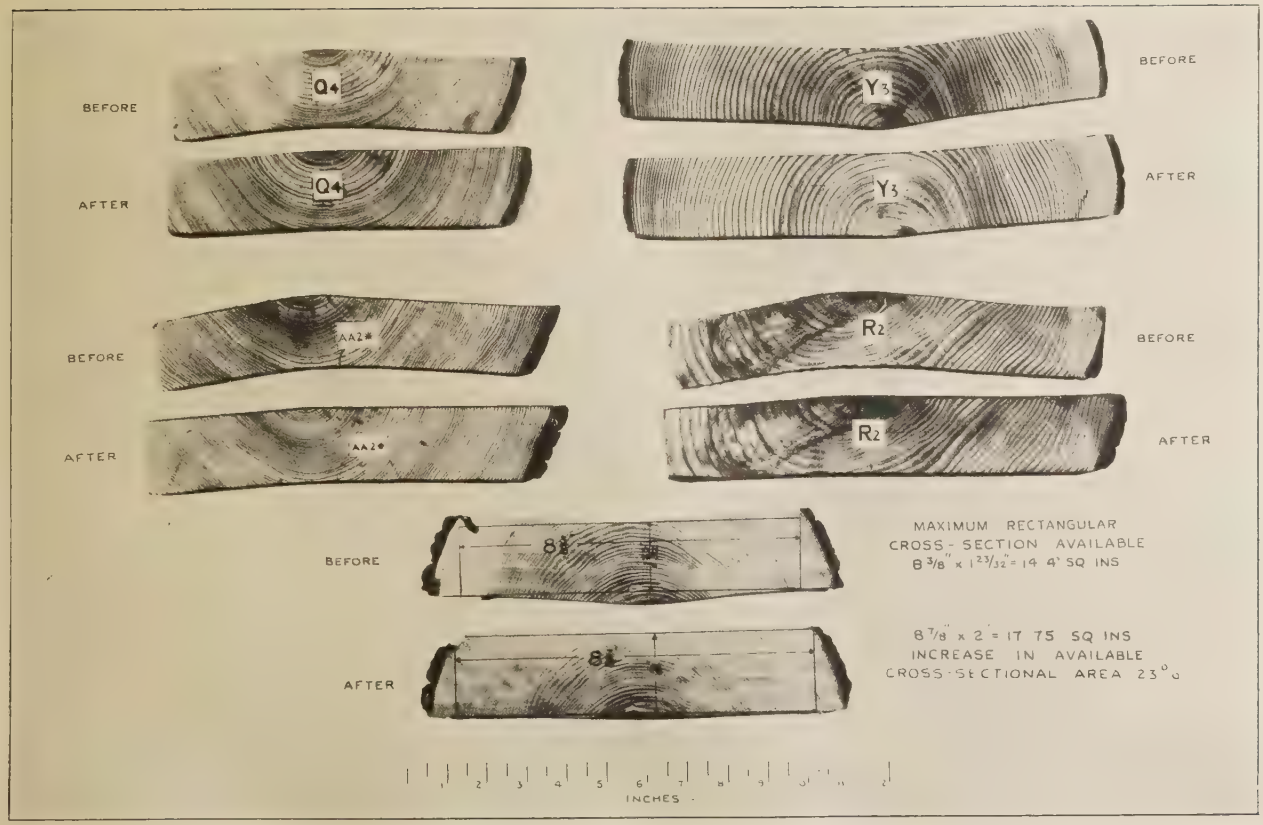


FIG. 3.—*Cross sections of ash planks cut before and after reconditioning.*

Ash was found to season satisfactorily from a green state and the only defect of importance was a somewhat excessive cupping. When this had been removed by means of a re-conditioning treatment (see page 12) the timber was in excellent condition.

The softwoods presented little difficulty, although it was clear that Norway spruce was slightly less tolerant of severe humidity conditions than the others.

The small-scale test of yew indicated that this species has a relatively small shrinkage. As a result, very little cupping was found even in wide through-and-through sawn boards, while in spite of obvious irregularities of grain, the warping was almost negligible.

Re-conditioning.

In last year's annual report an account was given of the successful removal of a defect, known as collapse, from Tasmanian oak by means of high-temperature steaming.

The treatment, which has been called re-conditioning, consisted essentially of warming the timber, which was first dried to a moisture content of 15 per cent., or lower, to 210° F. in saturated air, and then maintaining those conditions for four hours (in the case of timber 1 inch thick).

The results of the re-conditioning of Tasmanian oak were so pronounced and so successful that no time was lost in testing the effect on other species. A mixed parcel of kiln-dried common, Wych and Dutch elms, in the form of flooring strips 3 in. by 1 in., which showed not only collapse in the cross-section but other severe forms of distortion as well, offered an early opportunity for experiment. Excellent results were again obtained. The collapse, which though slight in the Dutch and Wych, was severe in the common elm, was practically all removed. Moreover, the more general distortion, such as cupping, bowing, and warping, was very considerably reduced and the quality of the timber correspondingly enhanced. No serious splitting resulted. There was, of course, an increase in the cross-sectional area of the timber, but in view of the removal of the collapse this was not considered to be remarkable, and it was chiefly the general straightening and flattening of the timber which led to the next investigation.

A load of 2-in. beech planks was next re-conditioned. This timber had been kiln-dried. It had no obvious collapse, except perhaps in one or two pieces, in which a slight irregularity of the section might have been attributable to this defect. Some of the planks, however, had cupped or warped considerably and the behaviour of these pieces during re-conditioning was specially observed. As in the case of the elm, these distortions were reduced to a surprising extent, and though the beech split much more than the previous species, this defect was still not serious from the view of most practical purposes. The most interesting feature noted, however, was the increase in the cross-section of the beech as a result of re-conditioning. In spite of the fact that the shrinkage of the timber during seasoning had been normal and not excessive as in the case of the collapsed Tasmanian oak and elms, there was a slight increase in thickness and an even greater one in the width of the planks, making a total increase of roughly 5 to 6 per cent. of the cross-sectional area.

Perhaps no re-conditioning treatment so far, however, has been more effective than that of some ash in the form of planks 2 in. in thickness. This had first been carefully kiln-dried without any serious defect except slight warping and considerable cupping; the extent of which as compared with that found in air-seasoned ash was largely accounted for by the greater dryness of the kiln-dried timber. The result of the re-conditioning treatment can be gauged from Fig. 3. The warping disappeared, and the cupping was greatly reduced, thus enormously increasing the material available for use in the

form of wide plank. Examination of the cross-section illustrated will show, however, that there is also an appreciable increase in both thickness and width. On the average the thickness increased by over $\frac{1}{16}$-in., sometimes by as much as $\frac{1}{8}$ in., and the width to the extent of $\frac{3}{8}$ in. or more per foot. The effect of drying and re-conditioning can perhaps be appreciated most clearly from the fact that finally the timber, at 15 per cent. moisture content, was practically flat, less than $\frac{1}{16}$-in. thinner than when sawn from the log, and with its width reduced by about $\frac{1}{4}$ in. in the foot. Tests already made tend to show that the strength after re-conditioning is unimpaired.

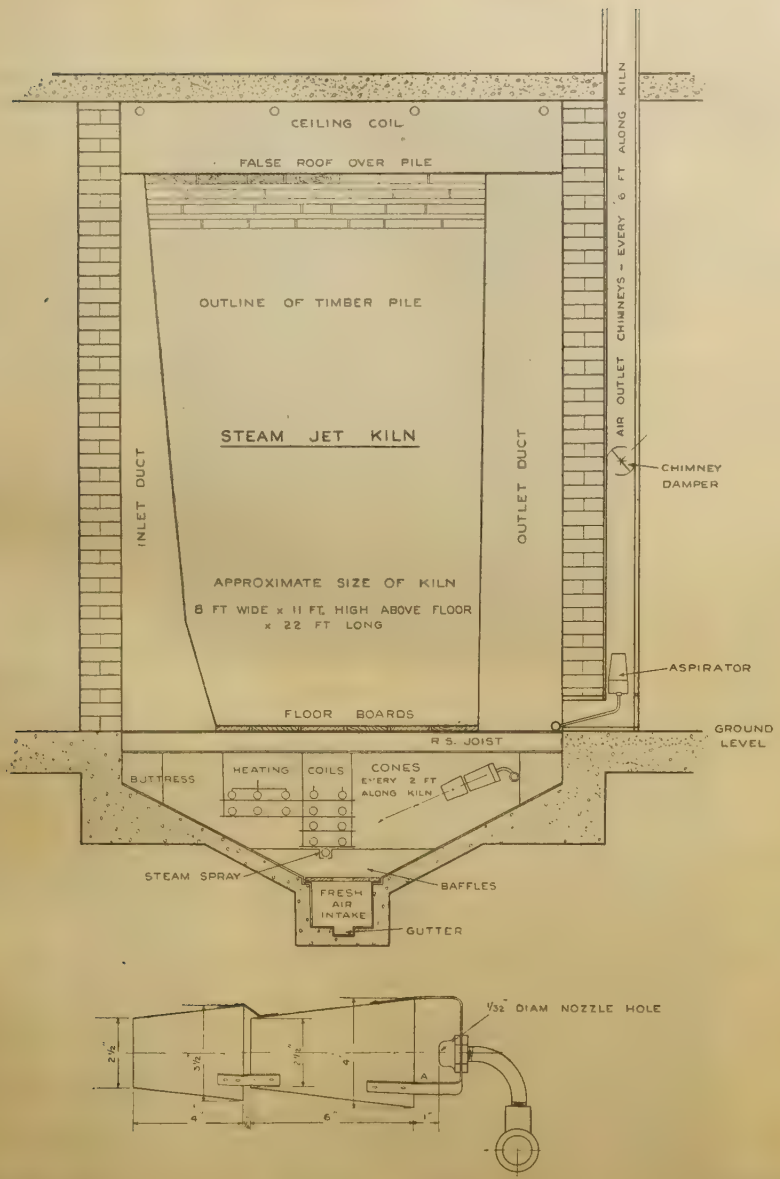
The Laboratory measurements of the thermal expansion of timber which are being made and which have already been mentioned (see page 9) make it appear probable that the removal of distortion and the increase of the cross-section caused by re-conditioning is a thermal effect. There is evidence of this, too, from the re-conditioning experiments themselves.

Modifications and Extensions to Kilns and Plant

The equipment of a new kiln has been completed during the year. The kiln is fitted so that it can be used alternatively as an external or an internal fan kiln, while in each case the circulation is downward from above, in contrast to the arrangement of the earlier kilns of these types. The chamber has already been in successful use as an internal fan kiln. In this form of kiln, the fans used are of the propeller type, and some irregularities in the air circulation have been noticed to be due to the swirling motion of the air after leaving the blades. To correct this, a simple form of baffle has been devised and placed near the discharge side of the fan, with excellent results. The advantage of the new internal fan kiln, as compared with the old, lies chiefly in the cheaper construction possible. No basement is required, for the fans and heating coils are placed above the kiln chamber, and consequently the comparatively heavy floor necessary to support the load of timber over the basement is also unnecessary.

The Laboratory has for some time been interested in the natural draught type of kiln. While, in the strict sense, its field of usefulness is very limited, it has the merits of cheapness, simplicity, and the lack of moving parts. It is clear that a kiln which depends for its circulation on internal temperature differences, often precarious enough in themselves, must, with the slightest exposure, be affected by external weather conditions. This difficulty has been met with in the Laboratory's experimental kilns, and steps have been taken to overcome it by the use of steam jets to assist the circulation. This general principle is, of course, not original, but no data of the type and size of jet were available and experiments were made to determine a suitable design. A cone and jet arrangement was finally arrived at, which led to the kiln design illustrated in Fig. 4. This, while losing little of the simplicity of the natural draught kiln, provides not only a positive circulation but one of appreciable air-velocity. The new kiln can in no sense be regarded as a rival to the fan type for all-round work, and especially when the drying of green timber or of the freely drying species is concerned. It may well be worth consideration, however, where simplicity and cheapness, and not output and high efficiency alone, are concerned.

The large conditioning chamber, in which it is intended to complete the air-seasoning of test samples for the Section of Timber Mechanics, has been completed and is now in use. The samples are first air-dried to 20 per cent. moisture content or less under normal conditions, and then to the standard 12 per cent. in the chamber at a temperature of not



Cones and Nozzles for accelerating circulation. Aspirator cones as for the 6" × 4" portion only, with dimensions A 3".

FIG. 4.—*Steam jet kiln.*

more than 75° F. and humidities, falling, as the drying proceeds, from 65 to 55 per cent.

A battery of 12 small steam-heated drying ovens has been installed and has been found to cope with the moisture determination requirements of the Laboratory more efficiently than the few large ovens previously employed.

New Instruments.

It has frequently been noticed that the employees of commercial firms coming to the Laboratory for training in seasoning work find difficulty in using the chart or tables which give the relation between the readings of the wet and dry bulb thermometers and the relative humidity. Consideration of this matter has led to the drawing of a simpler chart and to the construction of a mechanical chart, somewhat resembling a cylindrical slide-rule.

A much further advance is represented, however, by two instruments which have been designed to give direct readings of the humidity. Both are adaptations of the wet and dry bulb thermometer, and are illustrated in Fig. 5.

The upper instrument, designed by Mr. R. G. Bateson, has for its basis the humidity nomogram which consists of a dry bulb thermometer scale, a parallel wet bulb thermometer scale and a third humidity scale. If the nomogram is drawn on paper, the humidity can be read at the intersection of its scale with a straight line joining the points representing the dry and wet bulb temperatures on their respective scales. By means of a simple and ingenious mechanism, the principle of this nomogram has been adapted to a mercury-in-steel wet and dry bulb thermometer so as to give, on two dials, a clear reading of the temperature and the humidity respectively. The arrangement would serve equally well with gas-filled thermometers or, slightly modified, with vapour-filled ones.

The second instrument devised by Mr. W. C. Stevens, needs little explanation. A light pointer pivoted at a point on the wet bulb pen arm, rests on a roller attached to the other pen: its point indicates the humidity on a chart, which is easily obtained from a calibration of the instrument.

Both instruments have been tested in a practical way and have given a satisfactory performance. Patents have been applied for.

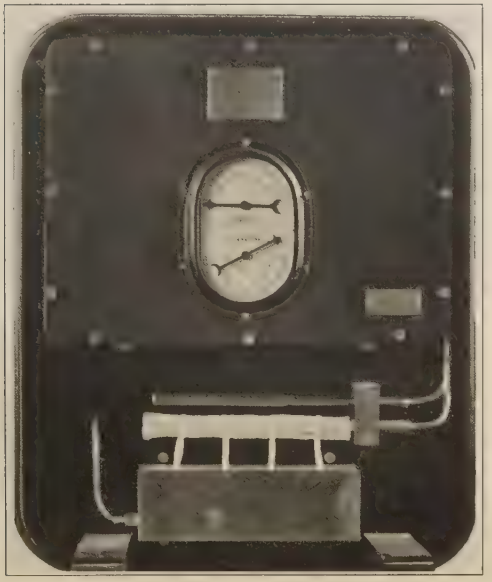
Air-seasoning and Combined Air- and Kiln-seasoning

Every effort has been made to collect information on the behaviour of different timbers under air-seasoning conditions, and piles have been erected whenever timber has been available.

In addition, a more systematic investigation into air-seasoning has been started. About ten piles were erected in March and April, 1931, at each of three sites, viz., in the Forest of Dean, at the Laboratory and near Thetford, Norfolk, and have since been under observation. It is hoped that by the autumn of 1932 the information collected will throw some light on the following points:

(1) The rate of seasoning of oak, beech, elm, larch and Scots pine in 1 in. and 2 in. thicknesses;
(2) The effect of leaving or omitting a space between boards in each layer;
(3) The effect of different thicknesses of piling sticks;
(4) The effect of the lateral space between piles;
(5) The effect of pile width; and
(6) The effect of raising the pile from the ground.

[To face page 14



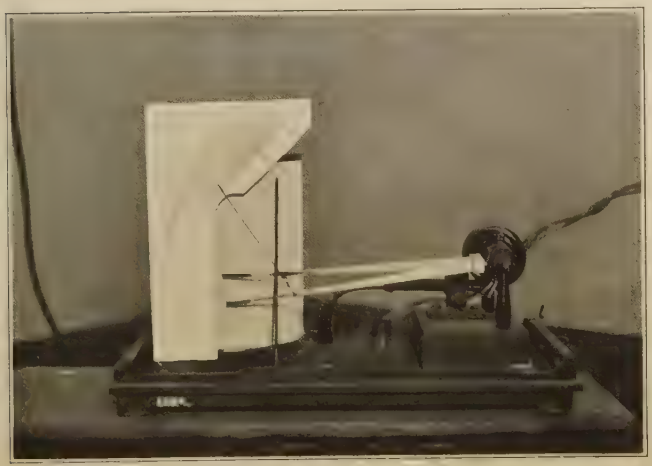


FIG. 5.—*Wet and dry bulb thermometers adapted to give a direct reading of humidity.*

The abnormal dampness of the summer of 1931 undoubtedly tended to mask small differences in the drying rates of samples, which might otherwise have been detected. There was some compensation, however, in the extent to which blue stain was able to develop in the Scots pine piles, and from the incidence of this defect, some important deductions could be made at once. For instance, $\frac{1}{2}$ in. piling sticks are obviously too thin for this species, and it was equally clear that two six-feet piles, even though separated by no more than a foot of space, are much more effective than a continuous stack twelve feet in width.

It is felt that the kiln-drying of certain of the more refractory hardwoods direct from the saw is a very doubtful economic proposition. For instance, oak in the form of planking 2 in. thick, requires at least two months in the kiln for careful and thorough seasoning. On the other hand, two or three years are necessary if the timber is to be thoroughly air-seasoned, and even after this period, it will still require further drying if it is to be used for interior joinery. The wide difference in the drying times required by the two methods makes the possibility of a combination of the two worth consideration. A project has been prepared to investigate the matter.

Steam Bending

The new steam bending laboratory was put into use at the beginning of the year, and steady progress has been made. Among other variables, the minimum moisture content necessary for bending is being investigated. Experiments have already shown that a considerable amount of seasoning may be permitted in beech without seriously affecting its bending qualities. This investigation is still far from complete, however.

The Chemical Aspect of the Drying of Timber

Research on this topic has been continued, and the results of the work on silver fir were published during the year.[1] It is frequently claimed that if ozone be introduced under certain controlled conditions to wood in the course of kiln-drying the resultant timber is in all respects indistinguishable from timber which has been thoroughly air-seasoned. Since the supposed advantages to be gained from ozone-treatment have frequently been described in vague terms, the Laboratory undertook a chemical comparison of the respective effects of air-kiln-and ozone-kiln-drying on matched samples of oak and Scots pine. The broad indications of the results[2] are that ozone in the concentrations used in commercial practice produces chemical changes in wood which appear to be closely analogous to those produced by ordinary air-drying and well-regulated kiln-drying. The evidence so far obtained, however, is not sufficient to indicate whether ozone confers any beneficial effect.

[1] Campbell, W. G., and Booth, J. The Chemical Aspect of the Drying of Timber. 2. The Drying of a Softwood. *Biochem. J.*, 1931, **25** (3), 756–762.

[2] Campbell, W. G., and Booth, J. The Chemical Aspect of the Drying of Timber. 3. The Effect of the Introduction of Ozone during Drying. (*In preparation.*)

The Effect of the Drying of Wood on the Yields and Composition of Hemicellulose

Previous work[1, 2] has shown that the chemical changes which take place in wood during various drying treatments are associated principally with the furfuraldehyde-yielding complexes in both the hardwood and softwood examined. Since the

hemicelluloses investigated at various times[3] have been shown to consist largely of these complexes and to exhibit marked instability towards heat it was decided to begin an investigation of the chemical constitution of the hemicelluloses of the wood of English oak with particular reference, in the first instance, to the effect on these substances of various methods of drying the original wood. Results so far obtained[4] have confirmed that chemical changes take place in wood during drying. With increasingly severe conditions of drying, the hot water and sodium hydroxide extracts of wood increase in amount and the yields of hemicellulose A decrease. The results further suggest that under drastic drying conditions such as prolonged oven-drying of green wood at 105° C. hemicellulose A is altered in constitution and gives rise to decomposition products which have yet to be identified.

[1] Campbell, W. G., and Booth, J. *Biochem. J.*, 1930, **24** (3), 641–648.
[2] Campbell, W. G. and Booth, J. *Biochem. J.*, 1931, **25** (3), 756–762.
[3] O'Dwyer, M. H. *Biochem. J.*, 1923 **17** 501–509. *Biochem. J.*, 1926, **19** 656–664. *Biochem. J.*, 1928, **22**, 381–390.
[4] O'Dwyer, M. H. The Hemicelluloses of the Wood of English Oak. I. The Effect of the Drying of Wood on the Yields and Composition of Hemicellulose A. (*In the press.*)

Influence of Kiln-seasoning upon Mechanical Properties of Timber

Mechanical tests to determine the effect of kiln-seasoning on the mechanical properties of home-grown timbers were carried out on material representing 23 kiln runs during the year. Material was obtained of species previously tested, from fresh localities, and the investigation was extended to include certain species not previously included.

The results of this year's tests confirm the conclusion formed as the result of earlier tests that kiln-drying, when properly carried out, has no detrimental effect on the strength of the timber and may on occasion produce values for the mechanical properties superior to those found for air-dried material of the same species.

Factors Affecting the Resistance of Timber to Wear

Various features for which correlation with the wearing properties is sought are hardness, specific gravity, rate of growth, percentage of summerwood and the angle of presentation of the growth rings at the wearing surface.

With the object of obtaining data, floors have been laid in different timbers, the material for which was first of all conditioned in strip form and then dressed as standard flooring stock. Some of this stock was retained as strip flooring while the rest was converted into standard flooring blocks. All the material was carefully identified and during the manufacturing processes identification of each separate piece was carefully preserved. It was thus possible to obtain material for the mechanical tests which was matched with the material placed in service in the floors, and the blocks and strips laid in the floors were numbered and an identification chart was prepared of the area covered by each of the species of timber. Each block and strip laid in the floor was subjected to hardness tests on the under surface.

Mechanical and Physical Properties of Timber

The testing of home-grown timbers was continued during the year. Seven consignments were collected, of which five were of species already tested but represented

material from new localities. A list of the consignments and their origin is given below :—

Specimen	From
Beech	Mapledurham, Oxfordshire.
Douglas fir	Longleat, Wiltshire.
Oak	Longleat, Wiltshire.
Scots pine	Weasanham, Norfolk.
Sitka spruce	Durris, Kincardineshire.
Willow (Bat)	Ryston, Norfolk.
Willow (Crack)	Ryston, Norfolk.

In last year's report several of the consignments had been tested in the green condition, but were at that time awaiting test after air-seasoning. These have now been tested.

The Conditioning Chamber

The long delay in reporting tests on air-dried material, which is occasioned by difficulties in seasoning under uncontrolled atmospheric conditions, has possibly reduced the usefulness of some of the reports. In other instances, where information on a species of timber has been urgently required, reports have been issued in an incomplete form, containing only the results of tests on the green material with perhaps further information concerning the kiln-dried timber. The advantages of conditioning the timber which is to be tested as air-dried in a chamber in which the temperature and humidity approach those encountered under ordinary atmospheric conditions at certain times of the year, and which would produce a definite though not drastic drying effect upon the timber have been recognised for some time. A conditioning chamber in which an atmosphere closely approximating to the conditions found in the open air on a good drying day in summer is maintained, was completed during the year, and it is hoped that in future it will be possible to report on the properties of air-dried material without serious delay.

The material to be placed in this chamber will be held, after conversion, in the air-drying shed, until it is found that the average moisture content of the consignment has fallen below 20 per cent. This will ensure that the seasoning will be carried through the period of fibre saturation under the ordinary conditions of air-seasoning, so that no modification either detrimental or beneficial will be made in the conditioned material as might be the case if the whole of the seasoning process were carried out in the conditioning chamber.

Testing of Timber in Structural Sizes

Considerable progress has been made during the current year on the testing of beams and joists in transverse bending. This investigation has been reported in previous years and the principle of the test has been explained.

The new bending apparatus with greater capacity, referred to in last year's report, was received in March and has since been used with success.

The testing of imported Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea excelsa*) timber has been completed. Testing has commenced on home-grown Scots pine from Douglas Castle, Scotland, and a further consignment of this species from Longleat, Wiltshire, is awaiting examination.

The results of tests on the imported Scots pine and Norway spruce timber are now undergoing analysis with a view to correlating the magnitude and frequency of the various defects found in such timber with the corresponding strengths as developed in the testing

machine. The great number of variables which enter into and affect these results make such an analysis a long and difficult operation and it is expected that the preparation of these results for publication will require careful study on the part of the officers concerned over a period of a year or more. During the past year 689 specimens in structural sizes were tested and in addition mechanical tests were carried out on 3,407 test pieces cut from clear material. The tests of the physical properties and other similar determinations numbered 9,515.

Tests on Greenheart Timbers in Large Sizes

A request was received from the Civil Engineering Department of one of the railway companies to produce figures representing the strength of greenheart timber in compression on the side grain (perpendicular to grain) on which could be based the design of large members of this timber in connection with a graving dock now under construction. To meet this request, a special test was designed, arranged and carried out on large specimens of the timber supplied by the company.

Tests on Douglas fir Sleepers to Determine the effect of Incising and Creosoting on Mechanical Strength

The problem of overcoming the difficulty of impregnating railway sleepers of Douglas fir with preservatives, particularly creosote, is one which must be solved if this important Empire timber is to compete successfully with the imported Baltic timber hitherto used almost exclusively for sleepers in this country. In order to overcome the difficulty of obtaining a satisfactory penetration of creosote into the timber it is necessary to adopt a method of treatment which is rather more severe than that required in creosoting pine sleepers, in that higher temperatures and pressures are necessary. An essential stage in the process consists of "incising" the timber before treatment in the creosoting cylinder. As some doubt has been expressed concerning the influence of this treatment upon the strength of the timber, it was decided to carry out some comparative tests, the results of which would indicate whether or not the strength was affected. These tests have been carried out on one consignment of Douglas fir, and arrangements are now being made to repeat the experiment and also to test sleepers of Baltic redwood so that a direct comparison may be made of the relative strengths of these two timbers after treatment.

Methods of Testing, Employing Test Pieces in Small Sizes

A system of testing is being developed to supplement the standard scheme detailed in Project I, "Mechanical and Physical Properties of Timbers" which requires that the material from which the test pieces are cut shall provide sticks dressed to a finished size of 2-in. square. In many cases where mechanical tests are required such material is not available and in others the material submitted for tests may be in the form of boards between 1 in. and 2 in. in thickness. A need for a scheme of testing, in which specimens of smaller sizes are employed, has long been felt and it is now proposed to employ test pieces having cross-sections of 0·8-in. square.

Suitable attachments for testing specimens of these smaller dimensions are being designed. The tests will include static bending, compression parallel to grain, hardness, cleavage and shock resistance or toughness.

Tests on material in thicknesses of less than 2 in. will be of considerable importance in determining the properties of timbers seasoned in the model kilns where the material

is usually in the form of small boards about 1 in. in thickness. They will also be of value in tracing variations in any characteristic or property throughout a sample of timber, and in determining the relationship between the mechanical and physical properties and the growth characteristics.

Relationship of Mechanical and Physical Properties

Investigations have proceeded during the year on the relationship of mechanical and physical properties and their correlation to the growth characteristics. Among these may be mentioned the following :—

Strength related to specific gravity.

Strength related to moisture content. (Fibre saturation point determined tentatively for a number of timbers.)

Shrinkage related to moisture content. Investigations have shown the relationship to be much more complicated than had generally been understood. Special tests are in hand to investigate more fully the points which have arisen.

Strength related to rate of growth. For Scots pine it has been established that timber grown in the South of Great Britain is stronger than timber of the same rate of growth produced in the North.

Special Tests on Home-grown Timber

A small consignment of false acacia (*Robinia Pseudacacia* L.) obtained from Norfolk has been tested in the green and air-dry conditions.

Improvements in Apparatus for Mechanical Tests on Small Clear Specimens

A suitable test in compression parallel to grain has been devised for work in connection with certain investigations undertaken by the Section of Timber Mechanics in co-operation with the Sections of Wood Structure and Mycology. The study of the mechanical methods involved in forming test pieces has resulted in a special variety turning lathe being installed which produces, with considerable accuracy, bobbin-shaped specimens to definite dimensions. These bobbins are either circular or square in section, the latter type of bobbin being particularly useful for the work undertaken to correlate the mechanical characteristics with the cellular structure. For this investigation specimens can be prepared having a definite integral number of growth rings in the section under test.

The testing of the bobbin test pieces involved the adoption of a special compression cage designed to give parallel loading on the ends of the specimen. The load is applied through ball bearing contacts and transmitted to the specimen by a spindle, which is made with a sliding fit in the cage. Possible errors due to eccentric loading are thus eliminated by the use of this attachment.

The Correlation of Structural Variation to Mechanical Strength

Previous work on the relation between the anatomical structure and the mechanical strength of wood has shown that it is impracticable to apply exact microscopic methods of examination to the standard test specimens 2 in. square used in the mechanical tests. During the year, a joint investigation by the Sections of Wood Structure and Timber Mechanics has been inaugurated, involving the use of the improved form of bobbin

compression test piece previously described. The advantages of this method are two-fold. In the first place, the portion of the bobbin which is actually under test can be made small enough to permit of its microscopic structure being thoroughly examined; and in the second place the test pieces can be selected with special reference to any particular growth characteristic, such as ring width, which it is desired to investigate. In carrying out the first series of tests on ash, the method adopted has been to select test pieces from cross-sectional discs which are slightly thicker than the final length of the test pieces. The position of the specimens is marked on the upper surface of the discs by means of a circular die, and the surface is photographed for purposes of record. The marked portions of the disc are then cleft out to ensure the direction of grain being parallel to the axis, and the bobbin-shaped specimens are prepared from the shaped blanks in the variety turning lathe. (Figs. 6 and 7.)

Timber Mechanics Committee

The Laboratory has been continuing, at the request of the Timber Mechanics Committee, various investigations in connection with the standard methods of testing in use. In addition to the reports already presented, others have been submitted upon the cleavage test, the tension-parallel-to-grain test, and the compression-parallel-to-grain test. A report on hardness was also made.

An extensive series of tests has been carried out upon the compression-parallel-to-grain test. Included in this series was an investigation into the relative merits of the square test specimen and the turned bobbin-shaped specimen (circular section). A report has been submitted covering tests on matched green and air-dry material, the result of the tests showing a slight increase in the apparent strength of timber when the bobbin type of specimen is used. Following on this investigation tests were also made to compare the results obtained with "long" and "short" bobbins, the former having a parallel portion twice the length of the latter, and the method of testing the square compression specimen was examined in detail. This matter involved tests to examine the effect of supporting the ends of the specimen on cone frusta and in rubber cushioned cups. Tests made with different lengths of square compression specimens showed no variation in apparent strength. As a result of the above investigations the Laboratory is now carrying out tests to determine what should be considered as the true strength developed in compression parallel to grain.

Further tests to determine the shear stress parallel to the grain in timber have been reported on. In this case, bobbin-shaped specimens were employed, cut with the principal axis inclined at various angles to the grain between 0° and 90°, the compressive force being applied in a direction parallel to the axis. The timber used in these tests was Scots pine in the green condition. The results confirm those obtained previously when using the square compression specimens.

Professor Coker has carried out photo-elastic experiments upon the shear test and has examined the system of stresses developed in the various types of test pieces used in this test. He is continuing his investigations and hopes to make a suggestion in connection with the F.P.R.L. No. 2. shear test piece which would make it very suitable for an approximate shear test.

Abrasion Tests

None of the standard abrasion machines in use has proved capable of adaptation to a standard abrasion test for timber. Recently experiments with various types of

FIG. 6.—*Improved form of bobbin-shaped compression test piece of ash (approximately natural size) for investigating the relation between anatomical structure and mechanical strength.*

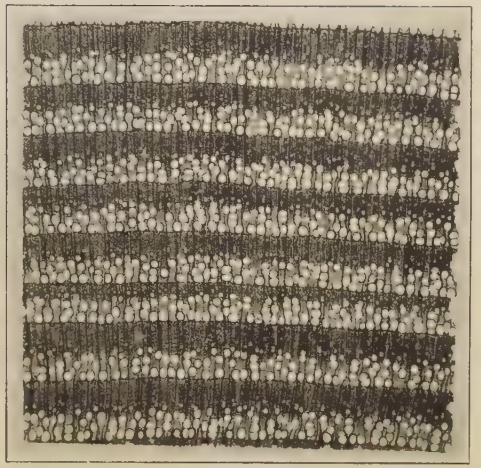
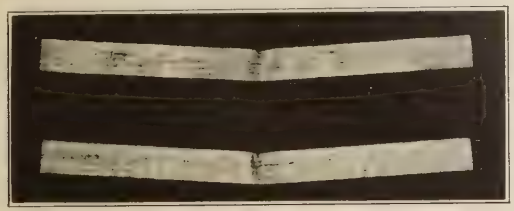


FIG. 7.—*Complete transverse section through the test piece at a a (Fig. 6) showing the structure of the wood (approximately five times natural size).*

Project 13. Types of failure of sterilised Sitka spruce specimens.



Project 13. Types of failure of Sitka spruce specimens after 10 weeks' incubation

FIG. 8.—*Types of failure of Sitka spruce specimens after ten weeks' exposure to fungus attack.*

composite abrasion discs have been made but difficulty in using discs in which the abrading agent is fixed was experienced, since instead of abrasion, a cutting action was obtained. Preliminary investigations are proceeding but much work will be necessary before a satisfactory standard test can be evolved. A memorandum has been prepared in which a survey of the problem, with an analysis of the different methods used in abrasion testing, has been made.

Mathematical Analysis of Results

An analysis, by statistical methods, of the variation in the strength properties of the timbers tested under Project 1, has been begun. The correlation between maximum crushing strength and specific gravity has been found for all consignments already tested and these results are being used in the detailed reports as they are published. Reference is made to these analyses in the recently published reports on the properties of home-grown Douglas fir[1] and of home-grown Scots pine.[2] The application of these statistical methods to the examination of results from mechanical and physical tests is being systematically developed.

[1] The Timber of Home-grown Douglas Fir. *Forest Products Research Bulletin*, No. 10. H.M. Stationery Office (1931). Price 3*s*. 0*d*. net.
[2] The Timber of Home-grown Scots Pine. *Forest Products Research Bulletin*, No. 15. H.M. Stationery Office, 1932. 5*s*. net.

Deterioration in the Strength of Timber due to Fungal Decay

As reported last year, the Laboratory is investigating the deterioration in the strength of timber attacked by *Trametes serialis* Fr. A report[1] has been published describing the methods of test, the technique employed, and the results obtained in two series of experiments upon the progressive loss in strength of Sitka spruce timber exposed to attack by this fungus. The decline in strength as measured by the static bending test was shown to be extremely rapid when conditions were favourable for the growth of the fungus. After only two weeks the strength fell by 20 per cent. and continued to fall rapidly until, after ten weeks when the experiment terminated, 80 per cent. of the strength had been lost. In the earlier stages the specimens failed by compression sometimes with slight splintering tension. As the effect of the decay increased, the compression tended to disappear and the tension to become increasingly brash. A few specimens in the advanced stage failed by longitudinal shear or tension towards one end. (See Fig. 8.) Although the wood may show, in the early stages, little or no sign of alteration externally, yet chemical examination indicates that an increase in the alkali solubility takes place at once and that its progressive increase can be closely correlated with the diminution in mechanical strength, measured as equivalent fibre stress at maximum load. On the other hand, loss in dry weight of the test pieces does not become significant until some weeks after the reduction of the strength begins and signs of chemical change become evident, indicating that the fungus is capable of altering the wood considerably before any appreciable quantity of wood substance is actually destroyed.

As a sequel to these tests, a further investigation was carried out in which compression parallel to the grain was substituted for the static bending test used previously, the same timber, Sitka spruce, being used. A special bobbin compression test piece was designed for use with inoculation flasks. The results obtained in the previous investigation have been confirmed by this series of compression tests, although the softening of the outside layers of fibres does not produce such an immediate and marked effect, and the decline

in strength following fungus attack is not so rapid as when measured by the static bending test. The investigations are being continued.

Considerable divergence of opinion exists as to the effect on the strength of wood of fungi which cause sap-stain and other discoloration, and it is proposed to conduct an investigation to determine whether these fungi actually have any deleterious effect upon the mechanical strength of the timbers affected by them.

Cartwright, Findlay, Chaplin and Campbell. Effect of Progressive Decay by *Trametes* [illegible] Fir on the Mechanical Strength of Sitka Spruce. *Forest Products Research Bulletin*, No. 11. H.M. Stationery Office, 1931. Price 1*s*. 6*d*. net.

The Preservative Treatment of Wood

Investigations into the effect of the structure of wood on its preservative treatment with antiseptics have been initiated. This problem has already received the attention of research workers, but, as a study of the literature has shown, knowledge of the fundamental principles of what may be called the theory of impregnation is still meagre. In the Sections of Wood Preservation and Wood Structure experimental work designed to elucidate the remarkable variation in the amenability of timbers to preservative treatment has been planned. Apparatus has been constructed to study in detail the path of liquid penetration through wood in different directions of the grain, and microscopic examination is being carried out on those structures which are believed to be of special importance in impregnation. The wide variation in the structure of different species of timber, the number of factors which may affect the treatment of any one consignment and the difficulty of distinguishing the effect of each separate factor, all combine to make this investigation exceedingly complex.

Mine Timber Durability Tests

The work of supervision and inspection of the pitprops of imported and home-grown Scots pine, which after treatment with different preservatives were placed in two mines, one near Nottingham and the other near Edinburgh, is being continued.

The Treatment of Douglas Fir Railway Sleepers

A preliminary report was prepared in 1930 on the creosote treatment of Douglas fir railway sleepers.

It was thought that the particular consignment on which the tests were undertaken might not have been representative of the whole of the Douglas fir imported into this country, so another consignment of sleepers was obtained and further tests carried out. The results varied considerably from those obtained previously and the difference could not be satisfactorily accounted for by variations in physical and anatomical structure. It would appear therefore that the influence of growth conditions as yet not discernible in the felled timber, would affect the resistance of the wood to impregnation with creosote.

The results again show the definite advantage to be gained from incising the sleepers before creosoting and indicate that the operation of incising is essential for the economic preservation of Douglas fir sleepers (Fig. 9). Since the publication of the preliminary report, a commercial machine has been installed in this country for incising sleepers and other large section material.

The final report has been circulated to various interests concerned and copies may be obtained on application to the Laboratory.

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FIG. 9.—*Sections of creosoted Douglas fir sleepers illustrating the deeper and more uniform penetration of creosote due to incising.*

Impregnation Tests on Different Species

The depth of penetration of antiseptics into wood is one of the important factors affecting its preservation. Consequently the ease with which different species of timber will absorb liquids is of considerable interest from the point of view of preservative treatment.

Figures for the relative permeability of different species are obtained by subjecting specimens of uniform dimensions to a standard pressure treatment, the absorption of liquid being taken as a measure of the permeability. Since penetration along the grain is invariably considerably greater than that across the grain, the amount of absorption of liquid by specimens of uniform size will vary according to the obliquity of the grain to the lateral surfaces. It is impossible to cut specimens perfectly parallel to the grain, and therefore a number of specimens must be treated in order to obtain a fairly correct average. Certain species, including Empire timbers of recent introduction, are being tested in this manner.

The determination of the permeability of wood to liquids is also directly connected with the use of timber for large vats. In the construction of these the ends of the planks are not exposed to the liquid and the direction of penetration is across the grain. For the purpose of comparison of the relative permeabilities of timbers suitable for vat construction a special apparatus has been devised whereby longitudinal penetration is eliminated and the liquid is forced under pressure solely in a lateral direction, the permeability being measured by the penetration obtained in a definite time under a uniform pressure. The specimens were machined in the form of small truncated cones $\frac{1}{4}$ in. thick which were sealed in brass containers by means of a mixture of resin and pitch. The impregnating liquid was placed on the top of the specimen and subjected to an air pressure of 78 lb. per sq. in., the depth of penetration being measured after 48 hours.

Standard Tests on Wood Preservatives

Work in connection with the scheme for testing wood preservatives has been continued. Treatment has been carried out with low temperature carbonisation tar and its distillate and also with three preservatives of the water soluble type. There is now a total of 4,800 specimens under observation, representing 8 preservatives. A few of the untreated control specimens have suffered considerable decay after 2 to 3 years.

Laboratory Testing of Wood Preservatives

The laboratory testing of preservatives, as described in previous reports, has been continued, and a further number of agar and wood block tests have been completed. Particular attention has been given to determinations of the toxicity of creosotes obtained from low temperature tar and of phenolic fractions distilled from them. Although the experiments are as yet incomplete, it may be said that the low temperature creosotes appear to possess a toxicity at least equal to that of ordinary creosote.

In connection with efforts being made to arrive at standard methods of test which shall be internationally comparable, the Laboratory has been co-operating in experiments to determine which strains of the various test fungi isolated by different workers shall be adopted for general use in all the laboratories concerned. The comparison of five strains of *Coniophora cerebella* has now been concluded and the most vigorous strain has been chosen for use in all future toxicity work. Similar experiments are now in progress to compare the different strains of various other test fungi.

Preliminary tests have been carried out upon a number of toxic substances including salicyl anilide (" Shirlan ") which has been proved to be extremely toxic to wood-destroying fungi.

An account of the Laboratory methods used for testing wood preservatives was presented by the officer in charge of Mycology to the Forestry Sub-Section at the London Meeting of the British Association and this has subsequently been published.[1] A contribution by the Assistant Mycologist to a discussion on the laboratory testing of antiseptics at a meeting of the Association of Economic Biologists will also shortly be published.[2]

[1] Cartwright, K. St. G. The Toxicity of Preservatives against Wood-destroying Fungi. *Forestry*, Vol. 5, No. 2, 1931.

[2] Findlay, W. P. K. The Laboratory Testing of Wood Preservatives. (*In the press.*)

Timber Insect Survey

The entomological work of the Laboratory during 1931 has shown that, as hitherto, the insects which cause most trouble in the hardwood timber and allied trades in this country are still the *Lyctus* Powder-post beetles. Requests for advice upon methods of preventing the damage caused by these insects have been more numerous than in past years and testify to the gravity of the problem they present. Accordingly, special attention has again been devoted to this subject, particularly in relation to the results of the extensive survey made throughout the country in 1929 and 1930, the main objects of which have been fully outlined in previous reports. It may be useful to recall that this work aimed at the collection of data upon the occurrence and distribution of *Lyctus* in imported and home-grown hardwoods in this country. The information now available from the survey should prove of much value in determining how best to prevent further increase and spread of these insects. A full report describing the work and the results obtained will probably appear before this report is published.[2] It will supplement the information in the previous publication on *Lyctus*.[1]

The prevention of damage by the *Lyctus* beetles is of vital importance to all trades and industries using susceptible hardwoods, e.g., oak, ash, walnut, etc. It is therefore essential that the trades involved should do their share towards solving this serious problem, by adopting methods of preventing the increase of these insects in their stocks. Whilst it is true that during the years immediately following the war quantities of *Lyctus*-infested timber came into this country from abroad, the results of the present investigation show that *Lyctus* is as frequent in home-grown as in imported timbers. The solution of the problem cannot be found therefore in legislation aiming at preventing the importation of infested timber, and little hope can be entertained of inducing exporters overseas to take steps until a widespread and thorough " clean up " campaign is put into operation in this country. The immediate remedy, therefore, lies in the hands of the timber trades and involves co-operative action on the part of exporters, importers, merchants, manufacturers, architects, builders, and all handling hardwood timbers. Whilst this work must depend largely upon the timber trades themselves, the Laboratory will readily offer technical assistance and advice on the efficiency of the methods adopted. Such help has already been given to firms which have sought assistance and which, acting on the advice supplied, have been able to reduce to a minimum their losses caused by *Lyctus* beetles.

Of the records obtained during the survey, the occurrence in English ash of the American species *Lyctus cavicollis*, not hitherto found in this country, is of particular

interest. This record is important as an example of an exotic species attacking home-grown timber and adds a third to the two American species of Lyctus (*L. planicollis* and *L. parallelopipedus*) already recorded in this country.

Whilst special attention was given to *Lyctus* during the survey, occasion was also taken to determine the extent of damage caused to hardwood timbers by other insects. Of these, the Pin-hole borers were found to be next in importance. Damage caused by these insects, especially in the tropics and sub-tropics, is of interest in relation to the exploitation of new timbers, some of which are very liable to infestation before being shipped.

(1) Fisher, R. C. *Lyctus* Powder-post Beetles. *Forest Products Research Bulletin*, No. 2. H.M. Stationery Office, 1928. Price 3*s*. 0*d*. net.

(2) Fisher, R. C., Cann, F. R., and Parkin, E. A. A Survey of the Damage caused by Insects to Hardwood Timbers in Great Britain. *Forest Products Research Bulletin*, No. 16. H.M. Stationery Office. Price 2*s*. 6*d*. net.

Kiln Sterilisation

Treatment by steaming in a kiln is still the most effective method of sterilising *Lyctus*-attacked timber. The treatment recommended[1] requires exposure of timber to 130 °Fahr. at 100 per cent. relative humidity for 1½ to 2 hours for 1-inch thick material and for longer periods for thicker timber. Further work has been carried out to determine whether lower temperature and humidity conditions together with longer periods of exposure would prove lethal. This work has included preliminary studies by the Seasoning Section of the Laboratory, upon the effect of varying humidity of the kiln atmosphere on the humidity conditions of the air within the timber. The results of the work so far carried out require confirmation before final conclusions can be drawn, but there is strong support for the belief stated in earlier publications of the Laboratory that treatment at 125° Fahr. and 80 per cent. to 100 per cent. relative humidity maintained over a period of several days, would prove sufficient to destroy *Lyctus* and sterilise infested timber. A point which has emerged from experiments upon the effect of high temperatures and humidities on *Lyctus* larvæ, and which has an important practical bearing, is their marked power of recovery after a heat treatment, which, insufficient to kill them, has, however, a prolonged paralysing effect. For instance, it took as many as 21, 28, and in one instance 43 days before larvæ removed from the wood and exposed to a temperature of 125° Fahr. and relative humidities of 60 per cent. and 80 per cent. could definitely be stated to be alive or dead.

(1) Fisher, R. C. *Lyctus* Powder-post Beetles. *Forest Products Research Bulletin*, No. 2. H.M. Stationery Office, 1928. Price 3*s*. net.

Susceptibility of Timbers to Lyctus Attack

Further information is still required upon the factors determining the degree of susceptibility of a timber to *Lyctus* attack. Attention has therefore been given to this problem during the year. Earlier work (Clarke, 1928)[1] has shown that a relation exists between the pore size of timbers and their susceptibility to infestation. Recent studies and experiments, together with records collected from the survey, show that although the theory originally formulated is partly sound, a modification is now required. For instance, records are available of the presence of *Lyctus* in sycamore and willow, and a case of particular interest is the marked susceptibility to *Lyctus* attack of the Australian

wood *Schizomeria ovata* which has small pores. The true nature of the relation between pore size and susceptibility to infestation can be determined only by further investigation of the mode of egg-laying of the insect. Work has been carried out on this subject; dissections of females have been made and the size and shape of the eggs before and after laying and the structure of the ovipositor have been studied. The information obtained, together with the results of the infestation experiments in progress will, it is hoped, throw further light on this interesting and important problem.

Although the structure of a wood may determine its suitability for egg-laying, successful development of newly-emerged larvæ, depends upon other factors. For example, it is known that *Lyctus* attacks timber during, or soon after, seasoning, and that as the timber ages, its suitability for the development of the insect decreases. Campbell[2] has shown that *Lyctus* apparently derives its nourishment from the cell contents of the sapwood. These contents vary according to the age of the timber and the suitability of a wood for *Lyctus* may therefore be limited to the period during which certain substances (e.g., carbohydrates)* are present within the cells. As was mentioned in the last annual report, an attempt is being made to obtain further information on the nutrition of *Lyctus* larvæ by treating samples of oak sapwood with various neutral solvents and then exposing them along with untreated controls to *Lyctus* attack. This work has been in progress during the past year, but results are not yet available.

* Since this report was written, Wilson has indicated (*Nature*, 1932, **130**, 22) that the food of *Lyctus* consists of starch. The Laboratory's investigations are, however, being continued, as the problem of the food relations of *Lyctus* with regard to susceptibility of timbers to attack has not yet been completely solved.

[1] Clarke, S. H. On the Relationship between Vessel Size and *Lyctus* Attack in Timber. *Forestry*, 1928, **2** (1), 47–52.

[2] Campbell, W. G. The Chemical Aspect of the Destruction of Oak Wood by Powder-post and Death-watch Beetles, *Lyctus* spp. and *Xestobium* sp. *Biochem J.*, 1929, **23** (6), 1920–23.

Death-watch Beetle—Xestobium rufo-villosum

During the past year many instances of the ravages of the Death-watch beetle in old buildings have been discovered, and interest has been aroused in this insect, which, although important, does not cause such widespread damage as the *Lyctus* beetles. Numerous inquiries have been received by the Laboratory for information upon the Death-watch beetle and the methods of control. A leaflet[1] briefly summarizing existing knowledge was published by the Laboratory in March, 1931; the wide circulation and extensive publicity given to this leaflet brought increased correspondence and provided the Laboratory with useful records of the distribution of the insect throughout the country. At the same time, the correspondence clearly showed that the damage caused by this insect is frequently confused with the less important and less serious damage caused by the Common Furniture beetle, *Anobium punctatum*, or even by the dry-rot fungus. The leaflet was prepared to facilitate correct diagnosis of the injury caused by *Xestobium* in order that costly repairs to buildings might be avoided where such measures were unnecessary.

The Death-watch beetle investigation which has been continued during the year, has again dealt primarily with the biology of the insect, special attention being given to the relation between the life of the insect and the conditions which affect its existence and propagation. The first systematic investigation of the *Xestobium* problem was begun in the Imperial College of Science and Technology by the late Professor Lefroy in 1914. Its object was to devise as rapidly as possible some reliable remedy against the

FIG. 10.—*Partly decayed Willows, the natural habitat of the Death-watch beetle.*

beetle's ravages. Many insecticide formulæ were drawn up, although knowledge of the beetle's life history and habits was scanty. It is believed that the acquisition of a fuller knowledge of the beetle and the biological problems it presents is the most useful contribution that the Laboratory can make to the solution of the Death-watch problem, but prolonged experimental work with an insect most difficult to handle is entailed.

An adequate supply of insects for this work has been difficult to obtain. With the assistance of architects and builders a large quantity of timber showing the characteristic Death-watch beetle damage has been collected, but the numbers of insects obtained from this material have been, as in previous years, extremely disappointing. Partly decayed willow trees in the neighbourhood of the Laboratory have proved a much richer source of supply than timber taken from buildings. Such old willow and oak trees (Fig. 10) are the natural habitat of *Xestobium*, and it may be assumed that when timber is badly attacked the conditions prevailing in it must correspond more or less closely to those of the insect's natural habitat. Confirmation of this is being obtained from experimental work in progress in the Laboratory. Investigations have been continued into the effect of variation in moisture content of timber at different temperatures, and of the presence or absence of fungus on the rate of development of the insect. At the present stage it would appear that the optimum conditions in timber for the development of *Xestobium* include a comparatively high moisture content and the presence of fungus attack. Even under such conditions the rate of growth of larvæ is extremely slow. The duration of the life cycle of the insect has been estimated by previous workers at two to three years; the Laboratory experiments show that it is more likely to extend to five or six years.

Observations have been made not only in the Laboratory, but also in the field, and in the roofs of buildings where damage has been caused. Advantage has been taken of the opportunity to collect information upon the occurrence of the insect and the extent of damage caused under different conditions in structural timbers, when at the request of architects and builders, inspections of attacked buildings have been undertaken.

As mentioned in last year's report, the roof of the experimental house erected at the Laboratory will be utilized for studies on the Death-watch beetle. During the past year it has not been possible to infest the building with this insect because suitable conditions for attack did not exist. Experiments are, however, being made to determine the most satisfactory method of obtaining the desired humidity conditions.

In the same report a brief outline of the problems involved in a study of the physiology of digestion of *Xestobium* and other wood-boring insects was given. Reference was made to the occurrence of micro-organisms, believed to be yeasts, in close relation to the alimentary canal of the insects, and of their apparent value for assimilation of wood. It was hoped to cultivate on artificial media the yeasts obtained from *Xestobium* and *Anobium*, so that their effect on cellulose or other wood constituents could be observed. During 1931, numbers of Death-watch beetles were dissected and cultures of the yeasts started on beef-peptone agar and beef-peptone gelatin. No yeasts which could be identified as those occurring within the beetles grew on the media, however. It became increasingly apparent as the work progressed that special methods of culturing and bacteriological technique were required for which the Laboratory was not equipped, and it appeared unlikely that this line of approach to the solution of the problem of nutrition of these insects would yield results. Investigations in this direction have, therefore, been suspended.

An exhibit of the Death-watch beetle and of the biological work in progress at the Laboratory was shown at the Royal Society Conversazione in June, 1931.

(1) The Death-watch Beetle. *Forest Products Research Leaflet*, No. 4 (1931)—obtainable from Forest Products Research Laboratory, Princes Risborough, Bucks. Gratis.

Incense and Death-Watch Beetle

Some preliminary experiments have been carried out upon the effect of incense on the Death-watch beetle. It has frequently been suggested that the use of this substance in churches may prevent attack by *Xestobium*. Larvae were removed from wood and exposed in a concentrated atmosphere of incense fumes for periods up to a maximum of two weeks. No visible ill-effects were apparent in any of the insects. No information is available upon the cumulative effect of incense but it seems unlikely that the use of this substance would have any deleterious effect on the larvae.

The Common Furniture Beetle—Anobium Punctatum

Work on the lines of the *Xestobium* investigations has been continued during the year with *Anobium*. Less attention has been paid to it, however, in view of the greater importance attached to other problems, but progress has been recorded and further data on the duration of the life-cycle of the insect under different conditions of humidity and in various woods have been collected. It has been very difficult to obtain adequate supplies of timber attacked by this insect ; parasites and predators have proved troublesome in depleting the stocks of insects available.

Description of Anobiid Larvae

A study, mentioned in the last report, of the morphology of larvae of the family Anobiidae has been completed. Detailed examinations were made and descriptions prepared of eight common British species. A report which includes keys for identification of the larvae has been prepared for publication.

Insecticide Tests

As in previous years, the Laboratory has been asked to advise on the value of, and carry out tests with, proprietary and other insecticides for the treatment of timbers attacked by wood-boring insects, and particularly by the Death-watch beetle. Determination of the toxicity of an insecticide for use against insects living at varying depths within timber presents a most difficult problem, which has not yet been solved.

Difficulties are presented by variation in structure of the wood samples and by differences in degree and distribution of insect attack, since no two samples are infested to the same extent. Consequently, uniform or standard samples are not available to enable strictly comparable tests to be carried out, until such standard material is prepared by infestation in the Laboratory, as is now being done with *Lyctus* and oak sapwood.

The choice of a suitable standard insecticide for comparison is another difficulty, but, meanwhile, this has been overcome by the adoption of orthodichlorobenzene as the standard in the tests so far carried out. It has not been found possible to use *Xestobium* for tests because of the impossibility of selecting samples of wood known to contain living insects. The results of the work carried out during the past year have shown that for laboratory tests *Lyctus* or the Anobiid beetle *Ptilinus pectinicornis* are the

two species which alone can be used. Both have disadvantages; *Lyctus* attacks only the sapwood, so that tests with this insect provide no data upon the powers of penetration in heartwood which is so important in the case of *Xestobium*. The damage caused by *Ptilinus* is not truly comparable with that due to *Xestobium* and, furthermore, this insect usually confines its attack to sycamore or beech, timbers rarely invested by the Death-watch beetle.

The difficulties which have been described above will show how unsatisfactory the testing of insecticides must necessarily be, and indicate that the results of the more or less rough empirical tests which have been carried out with a number of substances, including (at the request of the Chemical Research Laboratory), low temperature tar phenols covering a range of boiling points, have given only an indication of their comparative value. The future development of accurate and reliable laboratory tests of insecticides for use against wood-boring insects depends not only on the provision of standard material, but also upon information on the penetration of liquids and gases into timber and upon chemical studies of insecticides suitable for the control of wood-boring insects. An account[1] of the problems underlying the prevention and control of damage by wood-boring insects in this country was given to the Forestry Section at the British Association meeting in London, 1931.

[1] Fisher, R. C. The Prevention and Control of Damage by Wood-boring Insects. (*In the press.*)

Termite Resistant Timbers

The Laboratory is frequently asked for information upon the powers of resistance of different timbers to attack by white ants (termites). A number of references exist in entomological literature on this subject, but records of tests are few. In November, 1930, a circular letter was addressed to entomologists, forest officers, and others throughout the Empire, inviting information upon records of tests and the results obtained. During the past year replies have been received and valuable data obtained upon work now in progress on this subject.

Identification and Physiology of Wood-destroying Fungi

The collection of wood-destroying fungi growing in pure culture has been considerably increased during the period under review, both from new isolations and by exchange with other laboratories, and it now contains over 160 species. Thanks to the co-operation of mycologists in other parts of the Empire, cultures of a number of fungi causing decay of timber in the tropics have been obtained, and it is hoped to build up a collection of the most important tropical species so that it will be possible to identify the cause of decay in material sent in for diagnosis from abroad. Cultures and specimens of wood-destroying fungi have been received from Trinidad, Ceylon and East Africa, Workers in Canada, Australia and New Zealand, as well as in Great Britain, have been supplied with cultures from the Laboratory's collection.

The difficulty of distinguishing between the various white species of the genus *Polyporus* has led to a study of these forms in culture which it is hoped will give a clearer idea of the relationships in this group, which includes a number of important wood destroyers.

A note describing the appearance in culture of *Lenzites trabea*, *Polyporus fumosus* and *P. adustus* has been submitted for publication.[1] A paper has been prepared and

will shortly be published describing *Paxillus panuoides* and its effect upon wood,[2] together with details of some work carried out on the physiology of this fungus.

Further experiments have been carried out upon the influence of the concentration of nutritive matter in the medium in stimulating the production of fruit bodies by *Basidiomycetes* in culture, and efforts have been made to find a synthetic medium upon which these fungi can make vigorous growth. A medium which contains a fairly high percentage of hexose sugars has now been evolved on which many species grow almost as vigorously as on the standard malt medium; variations in the formula will be made in order to determine the individual influence of the various substances.

For the first time in this Laboratory, fruit bodies of *Merulius lacrymans* and of *M. minor* have been produced in culture upon agar media containing 10·0 per cent. and 2 per cent. malt extract, respectively.

A series of experiments are in progress to determine the effect of increasing the nitrogen content in wood upon the rate of decay by wood-destroying fungi. It is hoped that it will be possible when these results are available, to settle definitely whether the content of albuminous matter in wood influences to any degree its susceptibility to decay.

A preliminary investigation on the heat resistance of various fungi in agar medium has shown that many species are able to withstand temperatures far above those at which active growth ceases, for considerable periods. It is also planned to carry out experiments upon their heat resistance when growing in wood.

(1) Cartwright, K. St. G. Further Notes on *Basidiomycetes* in Culture. *Transactions of British Mycological Society.* (*In the press.*)

(2) Findlay, W. P. K. A Study of *Paxillus panuoides* Fr. and its Effect upon Wood. *Ann. App., Biol.* (*In the press.*)

Dry Rot Investigations

The experimental building, built according to plans supplied by the Building Research Station for the study of the conditions favouring dry rot outbreaks and of curative measures, was completed early in the spring of 1931. The ground floor consists of four rooms, the first is used as a preparation and inspection room, the second contains a series of small experimental solid floors laid with and without bituminous damp proof courses and in which the boards are fixed to the concrete in various ways. The third room contains all the undesirable features that are found in cheap, badly constructed houses; there is no ventilation under the hollow floors and the soil beneath is not concreted over—there is no damp proof course and the outer wall is solid. In the fourth room, on the other hand, the construction is good and every precaution has been taken to ensure that there is adequate ventilation under the floors.

In each of the experimental rooms the floor is in ten sections, which can be kept separate or joined as required, and all the boards, being fixed down with screws, are removable. On the walls are a number of half length panels, some of deal and some of oak, which have received various paints and varnishes. In places the panelling is connected with the woodwork of the floor above so that the interaction of beetle and fungus attack may be studied.

Every section of flooring and every panel was infected at the beginning of the summer with a piece of wood containing the dry rot fungus, *Merulius lacrymans*, in active growth, and the floors were covered with linoleum. The first inspection of the infected floors and panels was carried out four months after infection and it was found that in

FIG. 11.—*Dry rot experimental building. Growth of* Merulius lacrymans *on a certain type of solid floor four months from date of infection. At the extreme left is a piece of wood which is weighed at intervals in order to follow the changes in moisture content of the timber.*

FIG. 12.—*Dry rot experimental building. Growth of* Merulius lacrymans *upon joists in unventilated hollow floor eight months after infection with piece of rotted wood on the joist to the right.*

the "bad construction" room and on some of the solid floors the fungus had already made considerable growth, spreading several feet from the points of inoculation (see Figs. 11 and 12).

Short pieces of board are laid in various places both under and above the floor and these are weighed at intervals to determine their moisture content: in this way a record is obtained of the variations in moisture content resulting from the various types of construction, and a further record is kept of the temperatures both above and below the floors.

As soon as decay has reached a certain stage, it is proposed to test out various methods which have been suggested for sterilising *in situ* members such as joists, which are mechanically sound but carry traces of infection. The infected floors will also provide an excellent testing ground for determining the resistance to dry rot of various new Empire timbers which it is proposed to use for flooring.

The resistance to dry rot of various makes of wall board is being investigated. The majority of the pulp boards so far tested have proved susceptible to fungal decay provided they are kept sufficiently moist.

A leaflet[1] containing a brief description of the damage caused by *Merulius lacrymans* and other dry rot fungi, and of methods for preventing and curing an outbreak of dry rot has been published.

[1] Dry Rot in Buildings. *Forest Products Research Leaflet*, No. 6.—Obtainable from the Forest Products Research Laboratory, Princes Risborough, Bucks. Gratis.

The Chemistry of Decay

Research on the chemistry of the white rots of wood has been continued and the respective effects on wood substance of *Armillaria mellea* (Vahl.) Fr., *Polyporus hispidus* (Bull.) Fr., *Stereum hirsutum* Fr., and *Trametes pini* (Brot.) Fr., have been investigated. It has been established that the four examples of white rots examined have only one feature in common, and that this is shared by *Polystictus versicolor* (Linn.) Fr., which was dealt with in last year's report. In every case decay causes no marked increase in the total alkali-solubility of the residual major components of wood and in the case of *Polystictus versicolor* and *Armillaria mellea* this has been proved to be due to the fact that one component, namely, the pentosans not in the cellulose, becomes less soluble in 1 per cent. sodium hydroxide as decay proceeds. The white rots in question are thus sharply differentiated from the brown rots, for it has been found in some of the latter that even in very advanced stages of decay the residual wood substance is much more soluble in alkali than the original sound wood. For example, in a sample of the brown rot produced in Silver fir by *Paxillus panuoides*, there was a loss of 56·3 per cent. of the oven-dry weight of the original wood, 50·9 parts of which were accounted for by cellulose depletion. The alkali-solubility of the sound wood was 12·0 per cent. and that of the residue was 27·0 per cent. of the oven-dry weight of the original wood.

The general conclusion to be derived from the work on white rots is that these do not all attack wood in the same manner. For instance, while the rot produced by *A. mellea* possesses to some extent the visual characteristics of white rots and does not produce a marked increase in the alkali-solubility of the decayed wood residue a stage can exist in which lignin is apparently unaffected by the fungus. The other four examples can, on chemical grounds, be assigned to two separate classes as follows. While all four attack carbohydrates as well as lignin, *Polyporus hispidus* and *Stereum hirsutum* attack the pentosans in the cellulose and have little or no effect on the pentosans not in the

cellulose. *Polystictus versicolor* and *Trametes pini*, on the other hand, attack both categories of pentosans but preferential attack is made on the pentosans not in the cellulose. In the case of the "pocket" rot caused by *Sterum hirsutum*, it has been established that this fungus cannot be credited with a selective action on lignin. The white patches formed in wood decayed by this fungus merely represent localities in a decaying mass in which decomposition of both lignin and carbohydrates has progressed to a greater extent than in immediately contiguous material.

The Composition of Wood Smoke used in the Curing of Fish

Research on this subject has been continued. It has been found possible to isolate from smoke condensates constituents which are capable respectively of producing the flavour and colour ordinarily produced in smoked fish. The flavouring principle is composed largely of phenolic oils which are only present in small amounts in wood smoke. The colouring principle has not yet been identified but it appears to be present largely in the tar isolated from smoke. A series of preliminary experiments was carried out to determine the influence of variations in the conditions of burning of oak sawdust on the yield and composition of the resultant smoke and the indications are that the production of smoke of uniformly good quality depends in large measure on the regulation of the amount of air admitted to the wood during burning. It is proposed to extend these experiments in co-operation with the Torry Research Station in order to determine the type of smoke which produces the best quality in the finished product. A constitutional study of the various smoke constituents is in progress.

Forest of Dean Oak

Considerable quantities of oak in the Forest of Dean are of such poor quality as to be unsuitable for the uses to which oak of better class is usually put. In an endeavour to assist in the marketing of this class of material specimen flooring squares, built up in both block and strip form have been prepared and sent to the offices of the Forestry Commission as examples of one method of utilizing this material.

Investigation into the Working and Finishing Qualities of Wood

Considerable progress has been made in this work during the year. The methods of carrying out tests with standard tools have been improved and preliminary work in connection with investigations into the fundamental principles involved in machining wood has been commenced.

One of the most important factors in this work is the influence of the cutting angle of the tools on the finish produced and on the energy consumption of the machines. Difficulty is experienced in altering the cutting angle in most machines, e.g., in planing machines it can only be varied by front honing the cutters, whilst in spindle moulding machines variation is obtained by altering the projection of the cutters. It has been necessary therefore to evolve an attachment to planing and spindle moulding machines which will allow the cutting angle to be varied. The design has now been patented and it is hoped to have this device incorporated in a standard machine at an early date.

In addition, machine manufacturers have been approached with a view to the design of a thicknessing machine with easily removable cutter block so as to allow different cutting angles to be obtained by changing the blocks.

Major scale tests have been carried out under the revised working plan for standard tests, on oak (*Quercus Robur* L.) from six localities, Scots pine (*Pinus sylvestris* L.) from

two localities, and for comparative purposes upon imported redwood (*Pinus sylvestris* L.) from Upper Gulf, Sweden.

Charcoal Investigations

Investigations into the production, supply and uses of charcoal have been continued. Resulting from the experience gained in the working of portable kilns, the Buchanan-Harris type of kiln was evolved and patented. An experimental kiln of 240 cu. ft. capacity was manufactured for the Laboratory at a cost of £75. Subsequent laboratory and field tests carried out with this kiln enabled a comparison to be made of the efficiency of the type with that of the ordinary pit method of charcoal manufacture in the open, and led to the conclusion that the volume should be at least 480 cu. ft. for general commercial purposes.

During March, a tour was made to obtain the latest information regarding the economic production of charcoal in this country, the uses to which charcoal is put and the methods of grading employed by manufacturers and suppliers. Further experiments were then carried out at the Laboratory with the Trihan and Buchanan-Harris kilns on various grades of wood of different species, and of varying moisture content, over both long and short carbonization periods. Investigations were also carried out in carbonization at higher temperatures with the object of testing the possibility of producing a slightly activated charcoal.

Field experiments on a continuous working basis and using four kilns were conducted at Micheldever, Hants, over a period extending from the 19th October to the 17th November, 1931. During this period a demonstration was arranged to enable those from whom inquiries had been received, and others interested in charcoal production and charcoal products, to view, under field conditions, the operations in progress. The demonstration showed the piles of oak cordwood from local fellings ; weighing, sorting, and measuring operations, and the various stages of kiln operations.

Following on these operations, observations on the working of earth kilns at Western Common, Hants, were maintained over a period extending from the 23rd November to the 16th December. Reports of the investigations are in course of preparation.

Inquiries concerning charcoal production in all its phases, continue to be received from South Africa, East Africa, Kenya, Tanganyika, India, the Malay States, Dutch East Indies and the Argentine.

III. ADVISORY WORK

(*United Kingdom Section*)

General Utilization

There has been a large increase in the number of inquiries submitted during the year. Information has been sought relating to timbers for such widely divergent uses as marine constructional work, yacht and boat building, flooring, carriage and wagon work, artificial limbs, fruit and food containers, vats and cases for resisting the action of chemicals, mine timbers, wood-wool and wood-flour.

There have also been a number of inquiries relating to distillation and distillation products, and the use of charcoal for the generation of producer gas for the propulsion of motor vehicles.

The Structure and Identification of Wood

The services of the Wood Structure Section have been in frequent demand for advisory purposes. A large proportion of the inquiries has been concerned with the identification of wood in different forms, including commercial samples of timber and parts of wooden articles, veneers, sawdust, excelsior, wood fibre boards and archæological specimens. Inquiries involving identification have been received from commercial interests, architects, builders, public services, Government Departments and representatives of the Dominions and Colonies. Samples of timber are frequently accompanied by an inquiry regarding variation in quality, which is sometimes explained by the identity of the timber being contrary to specification but has very often proved to be due to some abnormal condition of growth having affected the structure or superficial appearance of the wood. In these cases, the Laboratory has been able to supply advice as to the effect of such structural abnormalities on the technical properties of the timber.

Seasoning

There was again an increase in the number of inquiries pertaining to seasoning during the year under review. More than 80 per cent. of these were from trade sources, asking for advice and assistance in practical problems concerning kilns, seasoning, and the moisture relations of timber.

Timber Mechanics

The Section received an increased number of requests for information. The following examples are typical :—

(1) The comparative stiffness and strength of joists of Baltic Scots pine and Canadian Douglas fir.

(2) The tests adopted in determining the mechanical properties of plywood.

(3) The relative values from considerations of strength, density, etc., of Canadian maple and Australian jarrah when used as flooring carrying heavy machinery.

(4) The relative strengths of English and American oaks with reference to their use in wagon construction.

(5) Details of a patent form of joint for constructions involving the use of large timbers.

(6) The fibre strength of Baltic Scots pine as represented in telegraph poles, as compared with the species of fir and spruce native in the United States of America.

Wood Preservation

Advisory work has continued to occupy a considerable proportion of the time of the Section and in this connection close co-operation has been maintained with the recently-formed British Wood Preserving Association. Technical advice has been supplied to the Association and assistance rendered in connection with exhibits at the Agricultural Shows and educational work generally. Matters of technical interest arising from the connection of the Association with timber users have been referred to the Laboratory and have proved useful in indicating what lines of research are of commercial importance.

Dry Rot and other Questions of Mycology

The amount of advisory work has continued to increase, the number of inquiries dealt with being more than double that received in the previous year. The majority of these have referred to dry rot in buildings, due principally to *Merulius lacrymans*, and in a number of cases it has been necessary to make a visit of inspection to advise as to treatment. Other subjects of inquiry have included questions as to the durability of various timbers, methods of testing wood preservatives, identification of fungal cultures, and " dote " in beech and oak.

Information has also been sought as to the cause and prevention of sapstain and discoloration in wood : in most cases, this type of deterioration has been found to be due to the growth of moulds and other fungi, but occasionally chemical agencies have been proved to be responsible.

Damage by Wood-destroying Insects

There has been a marked increase in the number of inquiries received by the Section of Entomology during the year under review. In addition to inquiries by letter, requests have been received for the inspection of buildings in which the woodwork has been attacked by wood-boring insects, with a view to the adoption of methods of prevention and control. Many visitors to the Section sought advice on problems arising out of insect damage to timber. The inquiries covered a wide range dealing not only with routine identifications of *Lyctus*, *Anobium*, *Xestobium* and other insects associated with timber, but including requests for information upon the value of insecticides and upon the susceptibility of timbers to termite or marine borer attack. As in past years, the Section has dealt with inquiries upon insect damage to timber on behalf of H.M. Office of Works, Air Ministry, and other Government Departments.

Representation on Outside Committees

The Laboratory is represented on the following Committees :—

Standing Committee on Empire Forestry :
(*Representative :* Director of Research).

Empire Forestry Association :—

Standard Names for Timbers—Sub-Committee
(*Representative :* Director of Research).

Governing Council
(*Representative :* Director of Research).

Publications Committee
(*Representative :* Officer in Charge, Utilization).

British Standards Institution :—

Building Industry Committee
(*Representative :* Officer in Charge, Utilization).

Revision of Aircraft Timber Specifications
(*Representatives :* Officers in Charge, Seasoning and Timber Mechanics).

Aircraft Technical Committee AC2 on Timber, Glue and Casein Cement
(*Representatives :* Officers in Charge, Seasoning and Timber Mechanics).

Sub-Committee, Standard Definitions and Tests for Fire Resistance and Incombustibility
(*Representative :* Scientific Assistant, Timber Mechanics).

Sub-Committee on Transmission Poles
(*Representative :* Officer in Charge, Timber Mechanics).

Technical Committee BG/19, Unit Weights of Building Materials
(*Representative :* Officer in Charge, Seasoning).

Empire Marketing Board :—
Empire Timber Publicity Committee
(*Representative :* Officer in Charge, Utilization).

Imperial Institute :—
Advisory Committee on Timbers
(*Representative :* Officer in Charge, Utilization).

Inter-Departmental Works Committee, Sub-Committee on Building Materials
(*Representative :* Officer in Charge, Utilization).

British Wood Preserving Association :
(*Member of Council :* Director of Research).

Publications Committee (Co-opted)
(*Representative :* Officer in Charge, Wood Preservation)

Technical Committee
(*Representatives :* Officers in Charge, Entomology, Wood Preservation and Scientific Assistant, Mycology).

Association of Economic Biologists :
(*Member of Council :* Officer in Charge, Mycology).

Imperial Conference :—
Forestry Sub-Committee
(*Representative :* Director of Research).

IV.—WORK FOR THE EMPIRE OVERSEA

1. General

Empire Timbers Committee

The work on Empire timbers under the auspices of the Empire Timbers Committee has again increased in volume. During the year preliminary tests on ten species have been in progress, and of these, five have been completed and reports have been issued on the results of the tests.

Special tests on three species which had been commenced before the beginning of 1931 have been continued and one has been suspended. Of the former, one test has been completed and will be followed by similar tests on a large scale on the same species. Small scale investigations have also been carried out for the Public Works Department of Nigeria and for the Director of Dockyards. Both of these have been completed.

No major scale tests have been undertaken owing to the difficulty of obtaining the relatively large quantity of material required for these tests in the time of financial stringency and forced economy through which the Empire has been and still is passing. One major scale investigation has been arranged, however, and is now being undertaken.

Commercial tests on two species are at present in progress and material for a third test of this nature is now at the Laboratory.

Collection of Information

The collection of information in accordance with the scheme outlined in the report for 1930 is being steadily carried forward. Some information is now available for practically every part of the Empire. The necessity for constant revision of the statistics already collected is not being overlooked and new information is being added as it becomes available. Much, of course, still remains to be done, and by the very nature of the subject of the inquiry it can never be complete, but nevertheless it is now possible to visualise with some approximation to accuracy to what extent the British Empire draws on outside forest areas for its timber supplies and also what is the extent of the export trade in timber from Empire sources to foreign countries. An attempt has been made to determine how far it would be possible to supply the whole of the Empire's demands for timber from Empire forests, and it would appear that a vigorous policy of development and exploitation of the forest resources of our colonies and dependencies could eventually render the whole Empire almost if not quite independent of all foreign supplies of hardwoods. Softwoods are in a different category, yet it is clear from statistics already obtained that there is room for a considerably greater consumption of Canadian softwoods within the Empire.

Co-operation with the Imperial Forestry Institute

The grant to the Imperial Forestry Institute for the maintenance of two investigators carrying out research on the classification, description and identification of wood has been continued. Papers on the anatomical variation in diffuse-porous hardwoods and on the wood structure of the family Sterculiaceae have been prepared for publication. A number of tropical African timbers have been described for the first issue of a series entitled, " The Forest Trees and Timbers of the British Empire," to be published by the Institute.

The Collection of Empire Timbers

The remainder of the specimens of timbers which were acquired from the Royal Botanic Gardens, Kew, the British Museum and other sources has now been converted into hand specimens and the species represented have been incorporated in the collection. In addition to the presentations and exchanges mentioned in the last report, a set of specimens of Empire timbers including 60 board specimens and 100 hand specimens, cut from the surplus of the material presented by the Director of the Imperial Institute, has been sent to the National Museum of Wales, Cardiff.

2. Programme of Work

Testing of Empire Timbers

The following timbers have been accepted for general preliminary tests since the last report was issued :—

1. Musisi .. .. *Maesopsis Eminii*, Engl. Uganda.
2. Musoga .. .. *Alstonia congensis*, Engl. Uganda.
3. Coachwood .. .. .. *Ceratopetalum apetalum*, D. Don. Australia.
4. Otutu .. .. *Mansonia altissima*, A. Chev. Nigeria.
5. Opepe .. .. *Sarcocephalus esculentus*, Afzel. Nigeria.
6. Podo .. .. *Podocarpus milanjianus*, Rendle. Tanganyika.
7. Podo .. .. *Podocarpus gracilior*, Pilg. Tanganyika.

The progress in the investigations of the species previously accepted is outlined below.

East African Camphor (*Ocoka usambarensis* Engl.), East Africa

The results obtained in the preliminary tests were so satisfactory as to warrant major scale tests being undertaken. This course was agreed upon by the Empire Timbers Committee, but owing to the difficulty of supplying material for these large scale tests through the necessity for stringent economy in the colony these have not yet been possible. An endeavour is being made to circumvent the difficulty by obtaining assistance from the trade interests, and co-operation in the form of reduced freight charges from the shipping company.

African Walnut (*Lovoa Klaineana*, Pierre ex Sprague)

Tests on this timber were undertaken to determine for the Timber Panel of the Sectional Aircraft Committee of the British Standards Institution whether the timber was suitable for use in the manufacture of air-screws. Tests on green and kiln-dried material have been completed, and a report has been issued. Material which has been air drying is now ready for test. The presence of gum streaks as a common feature in the timber may possibly prove a drawback as far as its use for air screws is concerned, but the tests amply confirm that it is a suitable wood for cabinet work, panelling and interior fittings. The demand for these purposes is increasing.

Sapele Mahogany

In connection with the air screw tests, three species of Sapele mahogany, namely, *Entandrophragma septentrionale*, A. Chev., *E. cylindricum*, Sprague, and *E. Candollei*, Harms., have been under investigation, and further tests of a fourth species, *E. utile*, Sprague, are contemplated when timber accompanied by herbarium material for confirmation of its identity can be obtained. Tests on the three first-named species in green and

kiln-dried condition were completed, and the report was issued in the latter part of the year. The tests showed that the timbers are not generally suitable for air screw manufacture, owing to a marked tendency to warping, due to growth characters. Examination of the structure of these three species has removed much of the obscurity which previously existed concerning the scope of the trade name "Sapele mahogany," and has also made possible the separation of the three different species tested by the aid of a hand lens alone.

It was formerly supposed that *Entandrophragma utile* was the principal source of Sapele mahogany, but during the progress of these investigations, large stocks of Sapele in a commercial yard were inspected, and it was obvious that a number of different species were included. Samples of these were obtained and compared with specimens of the three species, the identities of which had been determined from herbarium material, from which it became apparent that the same species is sold under different names, according to the port of export, and further that different species are sold under the same name. This is unsatisfactory, and it is hoped that the work which has been so successfully begun on these three species may be extended to embrace all the African timbers which are exported under the name of mahogany.

Crabwood (*Carapa guianensis* Aubl.), British Guiana

This species also is being tested as the result of the request of the British Standards Institution that research work might be undertaken to discover woods suitable for use for air screws. The tests of the mechanical and physical properties of the green timber are now practically complete, and other tests are proceeding.

Greenheart (*Ocotea Rodioei*, Mez.), British Guiana

Greenheart is quite well known on the markets of the United Kingdom, but its employment has been restricted to a few purposes, the chief of which is marine constructional work. For this purpose, large-sized timbers only are required.

The investigations now in progress have for one of their objects the discovery of uses for the smaller material which is unfit for marine work. The possibility of using this material for flooring will be explored and other outlets will be sought. The timber is reputed to be liable to "flake" in sawing, and workmen are also said to suffer from irritation of the mucous membrane when working it. These points will receive attention in the course of the investigation.

Wallaba (*Eperua falcata*, Aubl.), British Guiana

Wallaba is abundant in British Guiana, occurring in almost pure stand over large areas. For this reason it can be exported at a relatively low cost. At present, no export trade exists, and an outlet for the large quantities available would be of considerable value to the Colony. The tests on the species revealed the presence of a considerable quantity of gum which exuded from the pores for some time after cutting. Serious "honeycombing" occurred in the timber during kiln seasoning. The report stage has now been reached. Arrangements have been made, through the agency of the Director of Research, for Wallaba to be tested at one of the Forest Products Research Laboratories in Canada to determine whether the wood is suitable for the manufacture of paper pulp.

Purpleheart (*Peltogyne? pubescens*, Benth.), British Guiana

The timber of this species has arrived and tests will be commenced in the immediate future.

Meranti Tembaga (*Shorea leprosula*, Miq.), Federated Malay States

This species from Malaya closely resembles the "Red lauan," which is at present being imported from the Philippines. The tests were undertaken at the request of a British firm interested in the exploitation of Malayan timbers. They are now practically complete, except for the investigation of the working qualities, and a report will be issued shortly.

Keruing (*Dipterocarpus cornutus*, Dyer), Federated Malay States

This species also is being tested at the request of the British firm interested in Meranti Tembaga. The timber is very similar to the Apitong, which is being imported into the United Kingdom from the Philippines. A considerable and increasing trade in Philippine timber exists, and from figures published in the Manila Daily Bulletin on the 13th October, 1931, the value of this trade in 1930 was not very far short of £100,000. It should be emphasised that similar, if not identical timbers, occur in the forests of British North Borneo and Malaya.

The tests of the physical and mechanical properties of the green timber have been completed. Other tests are proceeding.

Santa Maria (*Calophyllumbrasiliense var. rekoi*, Standl), British Honduras

The material for tests has arrived, and arrangements have been made for the wood to be tested as to its suitability for veneer in addition to other routine tests. These will be completed in 1932.

Special Tests.

The following new applications for tests of a special nature were considered and accepted by the Empire Timbers Committee during 1931 :—

Blackbean (*Castanospermum australe*, A. Cunn.), Australia

Following the very successful results achieved in the elaboration of a process for reconditioning Tasmanian oak, a request was received for further investigations into "collapse" in Blackbean. This latter is a highly decorative and valuable timber, but as is the case with Tasmanian oak, the defect known as "collapse" develops in transit. Arrangements are being made for a supply of material, and collaboration will be maintained with the Forest Products Research Laboratory of the Commonwealth of Australia during the progress of the investigation.

Queensland Walnut (*Endiandra Palmerstonii*, C. White), Australia

This handsome wood has a reputation in the United Kingdom for being difficult to work and for rapidly dulling machine tools, and a request that the working qualities should be tested was considered by the Committee and approved. The supply of the requisite material is arranged for and tests will be carried out in the ensuing year.

Turpentine (*Syncarpia laurifolia*, Ten.), Australia

This timber is said to be very resistant to the attack of marine borers when used for piling and marine constructional work, and is now being used for this purpose on an experimental scale at several places on the English coast. An application for a

specification of this timber for use in piling was received from the Falmouth Docks and Engineering Company. Before the request can be complied with, tests of the mechanical properties, especially the resistance to compression parallel to grain, will have to be carried out.

Western Hemlock (*Tsuga heterophylla*, Sarg.), British Columbia

Several firms in the United Kingdom have made inquiries concerning this timber, and the Committee agreed that tests of the working and finishing qualities and the resistance to decay of this timber should be undertaken as opportunity occurred.

Western Red Cedar (*Thuja plicata*, D. Don), British Columbia

This species has also been the subject of several inquiries, and its durability has been called into question. The Committee therefore agreed that its seasoning and finishing qualities and its resistance to decay should be investigated. It was decided that the other special tests should take precedence over these British Columbia species as being of greater urgency.

Of the special tests approved before the beginning of 1931, the tests on Abura and East African Pencil Cedar are still proceeding.

Abura (*Mitragyna stipulosa*, Kuntze.), Nigeria

This was reputed to be acid-resisting to an unusual degree. Chemical tests which have been carried out indicate that the resistance of Abura to the action of 1 per cent. sulphuric acid at a temperature of 100° C. is equal to that of Bald cypress (*Taxodium distichum*, Richard), Pitch pine (*Pinus palustris*, Mill), and Teak (*Tectona grandis*, L.f.), the acid-resisting properties of which are already accepted. The tests were carried out at the request of Lloyds Shipping Agency who contemplated the possibility of using Abura to line oil tankers to prevent corrosion of the vessels' plates by the acid in the oil. Apart from this side of the question, however, a firm of British Battery Manufacturers is now co-operating to the extent of trying a consignment of the wood for the manufacture of battery separators.

East African Pencil Cedar (*Juniperus procera*, Hochst.), Kenya

The experiments to discover a means of softening this timber and seasoning it in such a way as to prevent warping after being made up into pencils, are still proceeding. The difficulty of softening the timber can now be overcome but seasoning experiments on pencil slats and blanks are not yet complete.

Mora (*Mora excelsa*, Benth.), Trinidad

A small scale test to determine whether Mora in the form of sleepers could be successfully treated with creosote, yielded results which, while inconclusive, were yet sufficiently promising to justify the greater expense of large scale tests. The approval of the Committee for these tests has been obtained.

Teak (*Tectona grandis*, L.f.). Mvule (*Chlorophora excelsa*, Benth., and Hook F.). Borneo Whitewood (*Parashorea ? plicata*, Brand)

A request was received from the Director of Dockyards for confirmation of the identities and comparative minor scale tests of teak, mvule, and Borneo whitewood, one

plank of each being sent. It was found on arrival that the moisture contents of the three planks differed very considerably. It was necessary, therefore, to bring all the boards to a uniform air-dried condition with a moisture content of 12 per cent. before any tests could be carried out. Examination of the structure showed the identities to be as stated above. The minor strength tests are now complete and the report is being prepared.

Commercial Tests

New Zealand Beech (*Nothofagus Menziesii*, Oerst)

The material which was received in November, 1930, has been distributed for commercial trials. The trials, which include tests to determine whether it is suitable for use (1) as rifle stocks, (2) for furniture, (3) for flooring, (4) for motor body building, are proceeding.

Indian Grown Honduras Mahogany (*Swietenia Macrophylla*, King)

Six logs of mahogany grown in Madras were received for commercial tests to determine how this timber compares with the Honduras grown material. On examination one log was found to contain bore holes which rendered it unfit for commercial tests and this was used for small scale tests of the mechanical and seasoning properties of the wood. The remainder of the material after conversion was distributed for commercial trials. The co-operation of H.M. Office of Works, a railway company and three manufacturers was obtained for the prosecution of the trials, and the results of the five trials will indicate to what degree the properties of the Indian grown mahogany agree with those of the native-grown timber.

Practical Trials of Empire Timbers

The trial floors which were laid in the corridors of the Laboratory in twelve different Empire timbers are all proving satisfactory to a greater or less degree. It is too early yet to report on the wearing qualities of these timbers, but they have been subjected to regular, frequent inspection for shrinkage and warping and in none of the floors has either of these defects been apparent to any noteworthy extent.

During the year the trials have been carried a step further. Mouldings have been made from twenty-four Empire woods and used in picture frames which will be distributed about the Laboratory. This trial will demonstrate the suitability of the woods for working on a moulding machine and will further be a test as to whether the woods will be subject to warping, twisting or uneven shrinkage when used in this form.

Co-operation of Trade and Shipping Interests

A suggestion was made at the meeting of the Empire Timbers Committee that timber firms and shipping companies would probably be willing to co-operate in reducing the cost to the Colonies concerned of supplying the material required for the tests at the Laboratory. This has been followed up and the results which have been achieved in the comparatively short time which has elapsed are distinctly encouraging.

Nigerian Timbers

Of recent years large quantities of timber from the Ivory Coast and the French Cameroons have been marketed in the United Kingdom and several timbers new to the markets of this country have appeared. With very few exceptions, the timbers which have been exported to the United Kingdom from the French possessions in Africa occur in exploitable quantities in Nigeria, the Gold Coast, Togo and the British Sphere of the Cameroons. Negotiations with British firms (one of which already has concessions in Nigeria) on the one hand and the Director of Forests of Nigeria and the Public Works Department of Nigeria on the other have been opened with the object of developing the export of Nigerian timbers on a more satisfactory basis.

The Natural Durability of Empire Timbers

The natural durability of timber is a property of considerable value where the timber is to be used under conditions which favour its deterioration. When the durability of the timber is of a very high order the timber may be used in its natural, untreated state for service out-of-doors, and large quantities of timbers such as oak and jarrah are used in this way.

As a result of centuries of experience, a very fair impression of the relative durability of the native European species is current, though, as far as is known, there are no definite figures for comparison. But there is practically no information available as to the relative durability, particularly in regard to the resistance to dry rot, of many of the tropical timbers now being marketed in this country, though frequently their behaviour towards termite attack has been noted. Numerous inquiries have been received at the Laboratory as to the relative susceptibility to dry rot of various Empire timbers, and it has hitherto been impossible to give any definite answer. It has therefore been decided to carry out a series of comparative tests on the resistance to fungal decay of native-grown species from the Empire overseas. Such tests fall into two classes: first, laboratory tests where small, carefully chosen pieces of wood are exposed to the attack of certain selected fungi under controlled conditions; and secondly, field tests in which posts are placed in the soil or in a rotting pit and their length of life determined. The tests of the second type have not yet been started, but a number of laboratory tests are already in progress. Samples of the timber, having a structure as far as possible typical of the species concerned, are exposed to fungus attack by being placed in contact with pure cultures of wood-rotting fungus growing actively upon artificial media in culture flasks. Each timber is tested against five fungi, and the amount of attack which has taken place is estimated by the loss in weight caused by the fungus.

Empire Timbers for Ornamental Turnery

During the year various species of Empire timbers were identified and conditioned, and one-hundred-and-twenty-four roughly turned cylinders of these timbers were prepared and sent to Mr. A. L. Hetherington. An illustrated report[1] has since been prepared by him which clearly demonstrates the suitability of these woods for various kinds of fancy turnery. The articles turned during his investigation will be placed on permanent exhibition at the Imperial Institute.

[1] Hetherington, A. L. British Empire Hardwoods from the Point of View of Turnery. H.M. Stationery Office (1931). Price 2*s*. net.

Advisory Work (Oversea Empire)

Contact with the Forest Services and other Laboratories of the Empire has been maintained. Numerous private firms have been in correspondence with the Laboratory on matters connected with the programme of research and with the choice of timber for special purposes.

A large proportion of the advisory work resulted directly or indirectly from the activities of the Empire Marketing Board.

Courses of Study for Research and Utilization Officers

During the period under review six other officers have attended at the Laboratory for courses of study, as shown below :—

Forest Services : India, 1 ; Burma, 1 ; Australia, 1 ; Kenya, 1.
Other Departments : Indian Ordnance, 2.

The total number of officers who have taken these courses is now twenty-nine.

R. S. PEARSON,
Director.

May, 1932.

APPENDIX I

LIST OF SCIENTIFIC AND TECHNICAL STAFF

Director of Forest Products Research : R. S. Pearson, C.I.E., F.L.S.
Assistant Director : F. M. Oliphant.
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APPENDIX II

LIST OF PUBLICATIONS

A.—*Stationery Office Publications**

	Price s.	d.
Report of the Forest Products Research Board for the period ended 30th September, 1928 .. .. (1929)	3	0
Report of the Forest Products Research Board for the period ended 31st December, 1929 (1930)	4	0
Report of the Forest Products Research Board for the period ended 31st December, 1930	4	0

TECHNICAL PAPERS :—

No. 1.—The Movement of Moisture with reference to Timber Seasoning. By S. T. C. Stillwell, B.Sc. .. .. (*Out of print*)		
No. 2.—Moisture Movement through Wood. The Steady State. By J. F. Martley, D.I.C., B.Sc. .. .. (1926)	1	3

SPECIAL REPORTS :—

No. 1.—The Air-Seasoning and Conditioning of Timber. By F. M. Oliphant .. (1927)	2	0
No. 2.—The Principles of Kiln-Seasoning of Timber. Part I.—Types of Commercial Kilns in Use. By S. T. C. Stillwell, B.Sc. .. .. (1928)	0	9

BULLETINS :—

No. 1.—Dry Rot in Wood .. .. (1928)	1	6
No. 2.—*Lyctus* Powder-Post Beetles. By Ronald C. Fisher, B.Sc., Ph.D. .. (1929)	3	0
No. 3.—British Hardwoods. Their Structure and Identification. By L. Chalk, M.A., and B. J. Rendle, B.Sc. .. .. (1929)	5	0
No. 4.—Decay of Sitka Spruce Timber caused by *Trametes serialis* Fr. By K. St. G. Cartwright, B.A. .. .. (1930)	2	0
No. 5.—The Moisture Content of Wood with reference to Furniture Manufacture. By S. T. C. Stillwell, B.Sc. .. .. (1930)	2	0
No. 6.—The Timber of Corsican Pine (*Pinus Laricio* Poiret) .. .. .. (1930)	2	6
No. 7.—Home-Grown Timbers. Their Anatomical Structure and its Relation to Physical Properties. Elm. By S. H. Clarke, B.Sc. .. .. .. (1930)	3	6
No. 8.—The Use of Home-Grown Larch Poles for Transmission Lines .. .. (1931)	2	0
No. 9.—Home-Grown Pitprops .. .. (1931)	2	0
No. 10.—The Timber of Home-Grown Douglas Fir .. .. (1931)	3	0
No. 11.—The Effect of Progressive Decay by *Trametes serialis* Fr. on the Mechanical Strength of the Wood of Sitka Spruce	1	6
No. 12.—Some Characteristics of Home-Grown Timbers. By C. J. Chaplin, M.Sc., M.E.I.C., J. Latham, B.Sc., and F. H. Armstrong, M.Sc., A.M.I.M.E. (1931)	2	0
No. 13.—The Principles of Woodworking: A Survey of Present Knowledge on this Subject. By W. W. Barkas, M.Sc., E. D. van Rest, B.A., B.Sc., and W. E. Wilson .. .. (1932)	2	6
No. 14.—The Determination of the Moisture Content of Timber. By R. A. G. Knight, B.Sc. (Eng.) .. .. (1932)	1	0
No. 15.—The Timber of Home-grown Scots Pine. (*Pinus Sylvestris* L.) .. (1932)	5	0
No. 16.—A Survey of the Damage caused by Insects to Hardwood Timbers in Great Britain, by Ronald C. Fisher, B.Sc., Ph.D., F. R. Cain, D.I.C., and E. A. Parkin, B.Sc., D.I.C. .. .. (1932)	2	6

* *Obtainable from any of the Sale Offices of His Majesty's Stationery Office, LONDON: Adastral House, Kingsway, W.C.2; EDINBURGH: 120, George Street; MANCHESTER: York Street; CARDIFF: 1, St. Andrew's Crescent; BELFAST: 15, Donegall Square West.*

PROJECTS :—

	Price s.	d.
Project 1.—Mechanical and Physical Properties of Timber. Tests of Small Clear Specimens. By C. J. Chaplin, M.Sc., M.E.I.C. .. .. .. (1928)	2	0
Project 1.—Progress Report 1. Tests of some Home-Grown Timbers in their Green Condition. By C. J. Chaplin, M.Sc., M.E.I.C. .. .. .. (1928)	0	9
Project 1. Progress Report 2. Tests of some Home-Grown Timbers in their Green and Seasoned Conditions. By C. J. Chaplin, M.Sc., M.E.I.C., and F. M. Mooney, B.Sc., A.M.E.I.C. .. .. (1929)	1	0

MISCELLANEOUS :—

The Uses of Home-Grown Timber. *Compiled by a Committee comprising representatives of the Land Agents' Society, The Federated Home-Grown Timber Merchants' Association, The Royal Institute of British Architects, and the Forest Products Research Laboratory* .. .. *Revised edition* (1929)	1	0

LEAFLETS :—

No. 1.—" Worm " in Furniture. By Ronald C. Fisher, B.Sc., Ph.D. .. .. (1927)		
No. 2.—The Influence of Certain Factors on the Kiln-Drying of Timber and on the Choice of the Types of Drying Kiln. By S. T. C. Stillwell, B.Sc. .. (1928)		
No. 3.—*Lyctus* Beetles and Their Control .. .. (1930)		
No. 4.—The Death-Watch Beetle .. .. (1931)		
No. 5.—Empire Timbers from Home and Overseas for Building and Structural Purposes. By Major J. R. Cosgrove, D.S.O., M.C., M.E.I.C. .. .. (1932)	1	3
No. 6.—Dry Rot in Buildings. Recognition, Prevention and Cure .. .. (1931)		

The unpriced leaflets above may be obtained only *from the Director, Forest Products Research Laboratory, Princes Risborough, Bucks.*

B.—*Other Publications*

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